THE

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'Knowledge is proud that he has learned so much,
Wisdom is humble that he knows no more.'—COWPER.

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Animal Physiology.

BY ARTHUR NEWSHOLME, M.D., AND C.S.S. (LOND.)

THE NERVOUS SYSTEM—*continued.*

THE chief importance of the medulla consists in its being a collection of centres for reflex action. It does not possess the power of initiating movements, except the cardiac and respiratory movements. Even in the frog, if the brain be carefully removed without touching the medulla, no movements occur, if it is left undisturbed. If any stimuli are applied however, reflex movements occur much more complicated and more closely simulating voluntary movements than those occurring after section of the spinal cord below the medulla.

Many complicated movements are controlled by the reflex centres in the medulla.

The following centres are the most important.

1. Respiratory centre.
2. Centre for inhibiting cardiac movements.
3. „ accelerating „
4. Vaso-motor centre.
5. Vaso-dilator centre.
6. Centre for dilatation of pupil.
7. „ closure of eyelid.
8. „ suction.
9. „ mastication.
10. „ insalivation.
11. „ deglutition.
12. „ vomiting.

The reflex movements regulated by the spinal cord may be diminished or even prevented (for a time at least) by the will of the individual. The reflex mechanisms of the medulla are more complicated and further removed from conscious existence. It is true that respiration can be stopped for a few seconds, but after a time the stimulus travelling up to the medulla from the lungs, and the stimulus furnished by the impure blood circulating in the medulla itself, are so strong that we can inhibit breathing no longer, and thus suicide by voluntary cessation of breathing is impossible. The cardiac movements are quite out of the control of the will or even the consciousness, though they may reflexly be influenced by emotion. The greater part of deglution is simply reflex. Once the bolus of food has been seized by the constrictor muscles of the pharynx, it cannot be rejected by an effort of will, but swallowing must continue till the act is completed.

The respiratory centre is situated in the floor of the fourth ventricle near its upper end. As injury of this minute point is followed by immediate and permanent cessation of respiration it was called by Flourens the 'vital knot' (*nœud vital*). The vaso-motor centre lies in the middle part of the medulla; while the centre for deglutition is higher up than that of respiration.

Structure of Cerebellum.

In the *cerebellum* as in the cerebrum the general arrangement of grey and white matter is the reverse of that of the spinal cord and medulla, the grey matter being superficial and the white matter internal. It is a bilateral organ like the other organs of the cerebro-spinal axis. It lies under cover of the posterior lobes of the cerebrum, being separated from it by a process of the dura mater. Its weight averages about 5 ozs. The grey matter forming its cortex or rind is arranged in thin plates, which are penetrated by offshoots of the white matter, giving to the cortex a tree-like appearance, known by the name of *arbor vitæ*.

Three layers are distinguishable microscopically in the grey matter of the cortex of the cerebellum. The outermost grey layer consists of rounded cells supported by a delicate network of neuroglia. The middle layer consists of a single layer of large ganglionic cells (of Purkinje) from which processes are probably connected to the axis-cylinder of nerve fibres. The innermost layer is granular and merges gradually into the white substance.

BRITISH MUSEUM

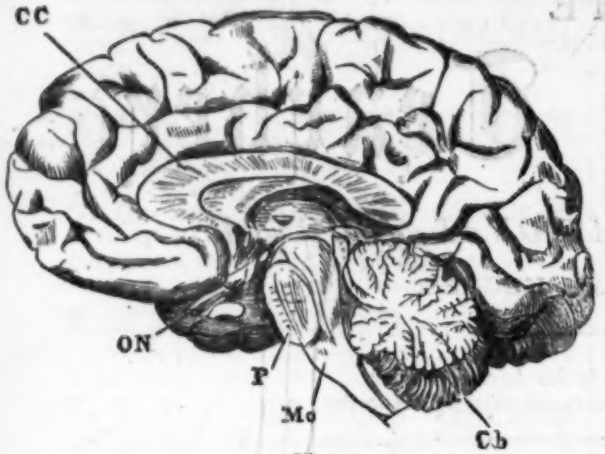


Fig. 92.

Section through middle of brain showing inner view of the different parts of encephalon.

C C—Corpus Callosum. O N—Origin of Optic Nerve. P—Pons. M o—Medulla Oblongata. C b—Cerebellum.

Three large bundles of nerves connect each half of the cerebellum with three other nerve centres, viz.—the medulla, the cerebrum, and the pons. The inferior bundle (*inferior peduncle*) is connected with the lateral part of the medulla oblongata. The *middle peduncle* passes on each side into the pons; and the *superior peduncle* passes forward and connects the cerebellum with the crus cerebri.

Functions of Cerebellum.

There is still the greatest divergence of opinion among physiologists as to the exact functions of the cerebellum, largely owing to the fact that disease of the cerebellum in man does not appear to be uniformly associated with the same phenomena as follow experimental lesions produced in the cerebellum of lower animals. One thing is certain, that injury to or removal of the cerebellum does not give rise to pain or muscular movement. All experimental results show that when a small portion of a pigeon's cerebellum is removed, the animal's gait becomes unsteady, that when larger portions are taken away, its movements become still more disorderly, and if the whole of the cerebellum is removed, it completely loses the power of co-ordinating its movements. The pigeon still retains power of sensation and of perception and volition, as evidenced by its efforts to escape from a threatened blow, which are only unsuccessful owing to the loss of power of combined muscular action. It is evident, therefore, that the only constant effect of lesions of the cerebellum is *muscular inco-ordination*. The cerebellum is the centre which presides over the general movements of the body, especially those required in maintaining equilibrium, walking, &c. The supposed connection of the cerebellum with the generative functions is more than doubtful.

The *pons Varolii*, or bridge of the brain (P, Fig. 92), is really a meeting-place of nerve-tracts between the other nerve centres. It is formed chiefly of the middle peduncles of the cerebellum, blending with the continuation upward of the medulla oblongata. Nuclei of grey matter are found in different parts of it, thus constituting it a nerve centre, as well as a mass of nerve fibres passing to other centres.

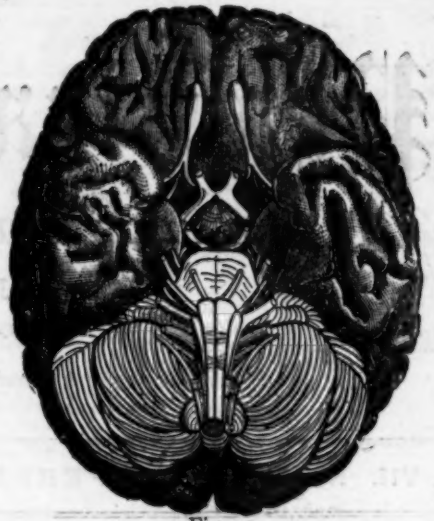


Fig. 93.

The Under Surface of the Brain.

Structure of the Brain.

The *encephalon*, or brain, is of ovoid shape, and is divided in the middle line by a deep fissure into two lateral halves or hemispheres. These hemispheres are connected at the bottom of the fissure by a broad band of white matter (corpus callosum).

The outer surface of the brain presents grey nervous matter arranged in folds, called convolutions or gyri. These convolutions are separated by fissures (sulci) of varying depth, which serve to divide the brain into lobes. By cutting successive slices from the upper part of the brain, its general plan can be studied. There is a cortex of grey matter (which penetrates the sulci), and an internal core of white matter. The corpus callosum forms the floor of a cavity called the *lateral ventricle*, in the interior of each hemisphere, which is moistened by a serous fluid. On the floor of each lateral ventricle the upper surface of the great ganglia of the base of the brain is visible. These are the *corpus striatum* and the *optic thalamus*. The corpus striatum is a pea-shaped body of grey colour lying in the anterior part of the floor of the lateral ventricle. It is divided into two masses of grey matter, which are separated from each other by a layer of white matter called the *internal capsule*. Behind and between the two striate bodies lie the optic thalami. Between the two optic thalami is a small space called the third ventricle. On the outer and back part of each optic thalamus are two small elevations (*corpora geniculata*). Behind and between the optic thalami are four rounded eminences called the *corpora quadrigemina*.

The arrangement of the nerve-fibres and nerve-cells in the various parts of the brain enumerated is somewhat complex. Of the nerve-fibres some connect the cerebrum with the cerebellum, pons, and medulla oblongata (*peduncular fibres*); some cross the corpus callosum, and join together the two hemispheres (*commissural fibres*); some join different parts of the same hemisphere (*arcuate fibres*); and others are roots of origin for cranial nerves.

Masses of grey matter, consisting of nerve cells, are contained in each corpus striatum, optic thalamus, corpus geniculatum, and corpus quadrigeminum; and these ganglia of the base of the brain are generally

regarded as 'middle men' between the spinal cord and the cortex of the brain. Some of these basal ganglia are motor and some sensory in function, and by their means are co-ordinated important reflex and automatic actions; while they in their turn are subordinated to the higher centres in the cortex.

When the nerve fibres are traced upwards from the basal ganglia to the cortex, they are seen to spread out like a fan, whence the name *corona radiata*. Their ultimate termination is in the nerve-cells of the cortex.

The external aspect of the brain is so variable that any exact description of its convolutions is difficult. It may, however, be divided into five lobes or territories, the frontal, parietal, temporo-sphenoidal, occipital, and central. These are of importance in studying the functions of different parts of the cortex.

The grey matter of the cortex generally consists of five layers, the thickness of the whole being in the adult from $\frac{1}{12}$ to $\frac{1}{8}$ inch. The outermost layer consists of a matrix in which delicate nerve-fibrils run between small nerve-cells. The second and third layers consist chiefly of pyramidal or spindle-shaped cells. The fourth layer contains small globular and irregularly branching cells, and the fifth spindle-shaped cells with long tapering processes. The axis-cylinder processes from the white matter of the brain probably become continuous with these branches of the nerve-cells. In the motor parts of the brain a preponderance of large multipolar cells has been found, corresponding to the large cells in the anterior cornua of grey matter in the cord.

Meynert's view is somewhat helpful in understanding the relation between the two different nerve-centres and the other organs of the body. He regards the grey masses and the converging and diverging tracts of nerve fibres as a 'Projection System' or a series of projection systems, capped and controlled by the cerebral hemispheres. Thus the sensory nerves form the 'feelers' and the motor nerves the 'arms' of its cortical grey matter.

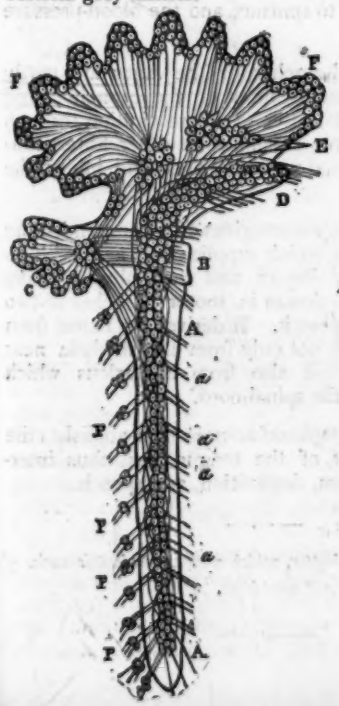


Fig. 94.

Plan of the central nervous system.

A A. Spinal cord. B. Medulla oblongata. C. Cerebellum. D. Masses of grey matter at base of brain. E. Thalami optici and corpora striata. F. Grey matter of cerebral cortex. *a a a*. anterior roots, and *p p p*. posterior roots of spinal nerves.

The cortex is a 'sensory shell' on which sensory impressions are gathered and interpreted; and is also a 'motor shell' in which motor impulses originate. In the former case it corresponds to the external sensory organs, the skin, the eye, the ear, the tongue, the nose, &c.; in the latter to the muscular system. The grey masses of the brain below its hemispheres may be regarded as 'interruption masses' of the projection system, or as belonging to the 'region of reduction' of the mass of this system. In them the tracts of nerves coming from the cortex are interrupted and re-issue greatly reduced in size.

The average weight of the brain is about 49½ oz. for the male and 44 oz. for the female. At birth it averages in the male 11·65 oz. in the female 10 oz. The proportionate weight of the cerebellum to that of the cerebrum is as 1 to 8½. The intellectual ability of an individual is not necessarily in direct proportion to the size of his brain. Much also depends on the degree of complexity of the convolutions and on the quality of the grey matter, which of course cannot be ascertained by any external cranial examination.

Functions of the Brain.

The cerebral hemispheres are the seat of all mental processes. They form the centres of memory, and through them the operations of thought and volition are performed.

The cerebral hemispheres are completely insensitive and may be removed without pain. Such removal in lower animals has always been followed by a stupor and apparent loss of intelligence. Sight and hearing are apparently retained, but no ideas are connected with these sensations. Thus the report of a pistol which would ordinarily excite evidences of terror in a pigeon, in the case of the pigeon destitute of its cerebral hemispheres simply produces evidence that the sound has been heard. Spontaneous movements, when the hemispheres are completely removed, seem to be entirely stopped. The evidence obtained from disease is somewhat less clear, as large portions of the brain may be destroyed without apparent impairment of function. If the basal ganglia are attacked, however, there is always paralysis of the opposite side of the body.

The experiments of Hitzig and Ferrier have shown that the application of electric currents to different parts of the cerebral cortex are followed by definite movements or evidences of sensation; while destruction of the same regions of the brain causes loss of motor power or sensation in the corresponding parts of the body.

In the following figure some of the more important localisations are shown. The centres for movements of the leg, arm, face, lips, and tongue, are situated from above downwards in the order named in the parietal region of the brain.

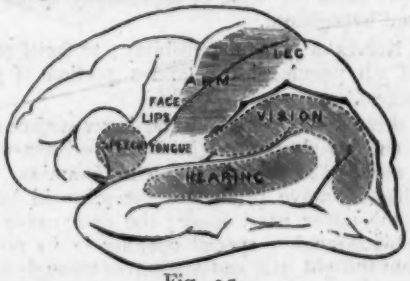


Fig. 95.

Outer surface of left side of brain showing special centres.

The regions for sensation are more difficult to localise, as excitation of sensory regions is not followed by muscular contractions. Centres for vision and hearing have been fairly well localised. (Fig. 95.)

One of the best described regions, known even before the previous experimental results, is the centre for speech. This is is the third left frontal convolution. (Fig. 95.)

Any lesion of this part, as in apoplexy, is followed by loss of power of co-ordinating the movements of articulation concerned in speech. Lesion of the corresponding part of the right side of the brain is not followed by loss of speech, except in left-handed people, who are therefore right-brained, and in whom the centre for speech is transposed. Whenever disease or injury of the right third frontal convolution is accompanied by loss of speech, a left-handed condition has been always found.

The Cerebral Nerves.

The cerebral nerves are generally described as nine pairs, but their number is in reality twelve, as the 7th nerve consists of two nerves, and the 8th of three. The usual classification is in accordance with the superficial origin from the brain from before backward.

The 1st pair or olfactory; the special nerve of smell.

The 2nd pair or optic; „ „ sight.

The 3rd pair or motor-oculi; distributed to all the muscles of the eye, except two.

The 4th pair; a motor-nerve to the superior oblique muscle of the eye.

The 5th pair; containing a motor root distributed to the muscles of mastication, and a large sensory root (tri-facial), the nerve of general sensibility of the face.

The 6th pair; a motor nerve to the external rectus muscle of the eye.

The 7th pair: containing (1) the portia mollis, or auditory, the special nerve of hearing; and (2) the portia dura or facial, a motor nerve distributed to the muscles of the face.

The 8th pair: containing (1) the glosso-pharyngeal; (2) the pneumogastric or vagus, and (3) the spinal-accessory nerves; all three mixed nerves with extensive distributions.

The 9th pair, or hypoglossal, the motor nerve to the muscles of the tongue.

These nerves may be classified according to their functions, as—

(*a*) Nerves of special sense; olfactory, optic, auditory, taste (from glosso-pharyngeal).

(*b*) Nerves of motion; 3rd, 4th, and 6th nerves to the eye muscles; motor root of 5th to masticatory muscles; facial (or nerve of expression), spinal accessory and hypoglossal.

(*c*) Nerves of general sensibility; tri-facial or large root of 5th, pneumogastric, and a portion of glosso-pharyngeal.

All these nerves start from the lower surface of the brain (having deeper origins in its substance) and leave the cranial cavity by special foramina. Thus the olfactory nerve penetrates the ethmoid bone to reach the upper nasal fossæ; the optic nerve enters the orbit through a special opening in its posterior wall, and the 3rd, 4th, and 6th nerves through another opening close to the former.

Injury to the 5th nerve would be followed by loss of sensibility of one half of the face and head, of one half the mouth, tongue, nasal fossæ, and the conjunctiva of the corresponding eye; also by loss of power in the muscles of the jaw controlling mastication. Certain minute nerve ganglia are situated on branches of the 5th nerve, the best known being the sub-maxillary, the relation of which to the secretion of saliva has been already considered.

Injury to the facial nerve (portia dura of 7th) produces paralysis of the muscles of the same side of face and palate. The eyelids cannot be closed, the mouth is drawn over to the opposite side, and, in speaking, one side of the face remains immobile.

The glosso-pharyngeal nerve has motor branches to certain pharyngeal muscles, ordinary sensory fibres which supply the back of the tongue, soft palate, and part of the pharynx, and special sensory fibres providing the sense of taste to the posterior third of the tongue.

The vagus or pneumogastric nerve has a wider distribution than any other nerve in the body. It has branches distributed to the larynx and pharynx, the lungs and heart, stomach, intestines and liver, spleen, pancreas, kidneys and bladder. At its upper part it receives a communicating branch from the spinal accessory nerve, which gives it motor fibres. A superior laryngeal branch gives off sensory fibres to the larynx, and an inferior laryngeal branch supplies the laryngeal muscles. Branches from the superior laryngeal nerve, and from the trunk of the vagus run to the heart. One of these, the depressor nerve, carries impulses up to the origin of the vagus in the medulla, which lower the energy of the vasor-motor centre, thus causing the blood vessels to dilate and the blood-pressure to fall, and at the same time the heart to beat more slowly. Other fibres of the vagus have an opposite effect, causing the heart to beat more rapidly, the arteries to contract, and the blood-pressure to rise.

The pulmonary branches of the vagus are partly motor to the muscular fibres of the bronchi; and partly sensory. The latter excite respiration through the respiratory centre; though some other fibres contained in the laryngeal nerves depress and inhibit the respiratory acts.

The *spinal accessory nerve* gives off a communicating branch to the vagus, which supplies the vagus with its motor fibres to the larynx, and its inhibitory nerve fibres, and then terminates in motor branches to two large muscles of the neck. It derives its name from the fact that it arises not only from the medulla near the vagus origin, but also from a nucleus which extends down into the spinal cord.

Section of the *hypoglossal nerve* in man abolishes the power of movement of the tongue, and thus interferes with mastication, deglutition, and speech.

A supplementary Chapter, which will conclude this series of Articles, will appear in our next issue.

Knitting Maps.

BY MRS. J. D. HARRIS.

GENTLEMAN'S VEST.

2 Bone pins. No. 11 Chamber's bell gauge.

12 oz. of Double Berlin or Scotch fingering.

The fronts of this vest should be knitted in a reversible stitch, as then they can be knitted exactly alike, except that in one side six buttonholes must be made, 3 inches apart.

A rib of knit 1, purl 1, is very elastic, and easy to do.

Fronts.

A. Cast on 4 stitches. Knit them once.

B. In the 1st stitch knit 1, and before you take it off the pin, purl 1 into the same loop. Repeat this in the 1st stitch of each row for 10 rows.

C. At the *end* of each row cast on 6 stitches over your thumb. (These 6 stitches must always be knitted back in the reverse row. Afterwards you must be careful to keep the ribs even.)

Repeat at C. till you have 62 stitches.

Pocket Hole.

D. Knit 28.

E. Cast off 22. Knit to the end of the row and at F.

F. Cast on 22.

Knit 7 inches.

Armhole.

G. Cast off the four 1st stitches at G. twice.

Knit 3 inches.

For Front of Neck.

H. Knit the 2 last stitches of each row at H. together.

To round the Armhole.

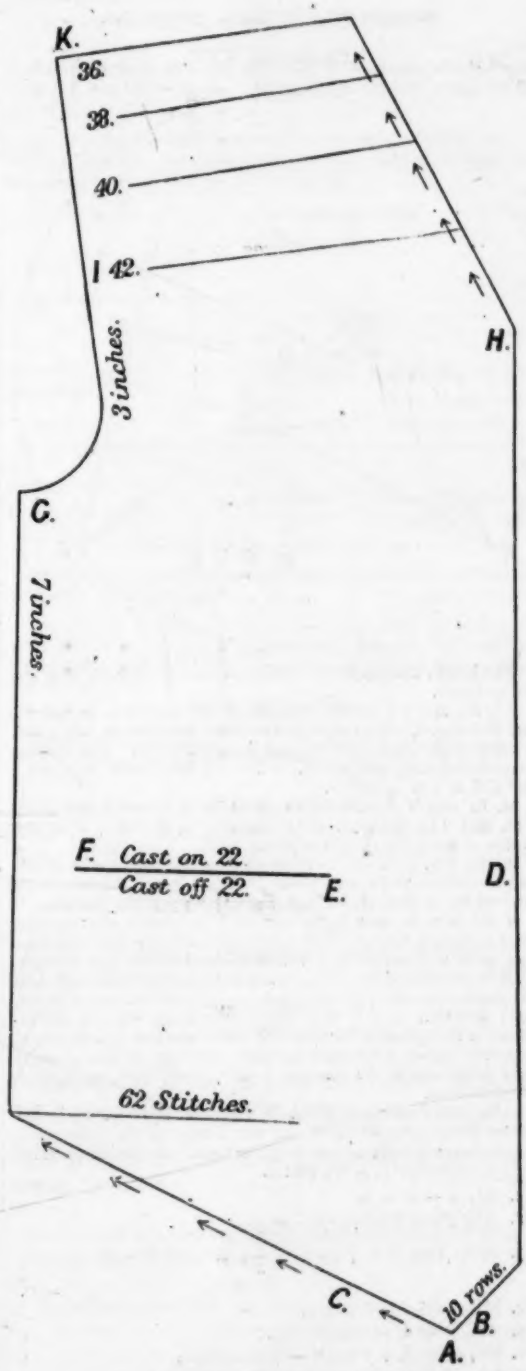
I. When you have 42 stitches add 2 at I.

At 40, add 2 more.

At 38, 2 more.

To slope the Shoulder.

K. At 36 stitches, cast off 6 stitches at the beginning of each row at K., still reducing 1 at H. till all are cast off.



Easy Steps in Trigonometry.

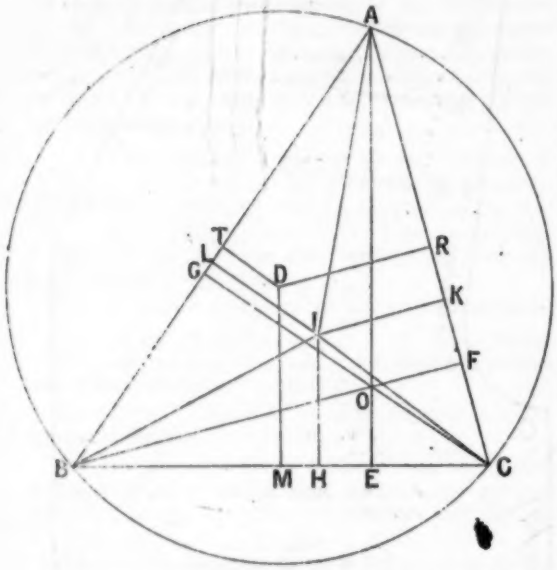
BY REV. A. D. CAPEL, M.A.,

Author of 'Catch Questions in Arithmetic,' etc., etc.

CHAPTER XXV.

HARDER EXAMINATION QUESTIONS.

314. EXAMPLES XXV.



The letters used in the first thirty seven questions refer to the above figure.

AI, BI, and CI are the bisectors of the angles A, B, and C, and therefore I is the centre of the circle inscribed in ABC, and it touches the sides in H, K, and L respectively. The student is reminded that AK or AL $= s - a$; BL or BH $= s - b$; and CH or CK $= s - c$.

M, R, and T are the middle points of a, b, and c, and MD, RD, and TD, being at right angles to a, b, and c, D is the centre of the circle described about ABC.

In the first fourteen exercises α, β, γ, are the lengths of the perpendiculars from any point in the several straight lines referred to, on the sides a, b, c, respectively, of the triangle.

If the point is taken in the several lines, outside the triangle, those perpendiculars which are drawn in the opposite direction from what they would be if the point were within the triangle must be considered negative, *e.g.*, in MD produced through AB, if a point were taken above AB, α and β would be drawn in the same direction as if P were within the triangle but γ would be drawn in the opposite direction and must therefore be considered negative; again if IB were produced through B and a point were taken outside the triangle, α and γ would both be negative but β positive.

In the first fourteen questions if any point P be taken in the several lines (some of which are not drawn in the figure) and from it the perpendiculars α, β, γ, be drawn to the three sides a, b, c, respectively, prove that in

1. AI, $\alpha - \beta = 0$.
2. AE, $\beta \cos B - \gamma \cos C = 0$.
3. MD, $\beta \cos B - \gamma \cos C + \frac{a}{2}(\sin C \cos B - \sin B \cos C) = 0$.
4. MR, $a\alpha + b\beta - c\gamma = 0$.
5. AM, $\beta \sin B - \gamma \sin C = 0$.
6. EF, $\alpha \cos A + \beta \cos B - \gamma \cos C = 0$.
7. ID, $\alpha(\cos B - \cos C) + \beta(\cos C - \cos A) + \gamma(\cos A - \cos B) = 0$.
8. AD, $\beta \cos C - \gamma \cos B = 0$.
9. DO, $a \cos A(\cos^2 B - \cos^2 C) + \beta \cos B(\cos^2 C - \cos^2 A) + \gamma \cos C(\cos^2 A - \cos^2 B) = 0$.
10. AH, $\beta(s - b) \sin B - \gamma(s - c) \sin C = 0$.
11. IH, $\beta \cos B - \gamma \cos C - (s - c) \sin C \cos B + (s - b) \sin B \cos C = 0$.
12. HK, $\alpha(s - a) \sin A + \beta(s - b) \sin B - \gamma(s - c) \sin C = 0$.
13. MK, $a\alpha(s - a) + \beta b(s - c) - \gamma c(s - c) = 0$.
14. MF, $ac \cos A + \beta b \cos C - \gamma c \cos C = 0$.
15. Express the length of AM in terms of a, b, and c.
16. Bisect ME in V and RF in W, and draw VN and WN perpendicular to a and b respectively, and find the length of VN. (*Note*:—N is the centre of the nine point circle.)
17. Find the area of the triangle ABC in terms of its sides without using the symbol s.
18. What does the expression in 17 become if $C = 90°$?
19. Produce AI to meet BC in X, and find the length of AX.
20. Find the length of DO, in terms of perpendiculars on a, b, and c, from D and from O.
21. From the equation in 9, prove that N (see Ex. 16) is in DO.
22. Show that the equations in 2, 3, and 11 (which refer to lines which are parallel to one another) only differ by a quantity which is independent of α, β, and γ.

In the following twelve cases, write down by symmetry the connection between the perpendiculars α, β, γ, from any points in the straight lines mentioned below, from that with regard to the perpendiculars from any point in the corresponding lines, as proved in the different examples named.

23. BI and CI from AI. (Ex. 1.)
24. BF and CG from AE. (Ex. 2.)
25. RD and TD from MD. (Ex. 3.)
26. BR and CT from AM. (Ex. 5.)
27. BD and CD from AD. (Ex. 8.)
28. IK and IL from IH. (Ex. 11.)
29. BK and CL from AH. (Ex. 10.)
30. RT and TM from MR. (Ex. 4.)
31. FG and GE from EF. (Ex. 6.)
32. KL and LH from HK. (Ex. 12.)
33. RL and TH from MK. (Ex. 13.)
34. RG and TE from MF. (Ex. 14.)
35. In examples 23 to 29 inclusive, prove that the three lines in each case must pass through a point.
36. Let p_a, p_b, p_c represent the lengths of AE, BF, and CG respectively, and prove

$$\frac{p_a^2}{p_b p_c} + \frac{p_b^2}{p_c p_a} + \frac{p_c^2}{p_a p_b} = \frac{bc}{a^2} + \frac{ca}{b^2} + \frac{ab}{c^2}$$

37. With the notation of 36 (r being the radius of the inscribed circle) prove

$$p_a p_b p_c = \left(\frac{a + b + c}{abc}\right) r^3$$

38. Find the value of $\sin 6°$.
39. Find the value of $\cos 13\frac{1}{2}°$.
40. Find the value of $\tan 4\frac{1}{2}°$.
41. Find the number of grades in the smallest angle of the triangle the measure of whose three angles expressed in grades, degrees, and circular measure are represented by the same number.
42. If $(x - d)$ (unit being circular measure), x degrees, and $(x + d)$ grades, be the three angles of a triangle, find them in circular measure.
43. Reduce $\sin\theta + \sin\phi - \cos\theta \sin(\theta + \phi)$ to a single term.
44. Show that $\frac{\sin\beta \cos\alpha (\tan\alpha + \tan\beta)}{1 - \cos(\alpha + \beta)} + \frac{\sin\frac{1}{2}(\alpha - \beta)}{\cos\beta \sin\frac{1}{2}(\alpha + \beta)} = 1$.
45. Solve the equation

$$\sin^2 2\theta - \sin^2\theta = \sin^2\frac{\pi}{6}$$

46. Find the necessary condition that the same value of θ may satisfy both the equations.

$$\left.\begin{aligned} a\sec^2\theta - b\cos\theta &= 2a \\ b\cos^2\theta - a\sec\theta &= 2b \end{aligned}\right\}$$

47. Given $\frac{x^2}{a^2}\cos\theta = \frac{y^2}{a^2}\cos(\theta+\phi) + \frac{z^2}{b^2}\cos\phi$

and $\frac{x}{\sin(\theta+\phi)} = \frac{y}{\sin(\theta-\phi)} = \frac{z}{\sin 2\theta}$

show $\frac{\sin\theta}{\sin\phi} = \frac{b^2}{a^2}$.

48. Eliminate θ from

$$x\sin\theta - y\cos\theta = \sqrt{x^2+y^2}$$
$$\frac{\cos^2\theta}{a^2} + \frac{\sin^2\theta}{b^2} = \frac{1}{x^2+y^2}.$$

49. Given $\frac{\cos x}{a_1} = \frac{\cos(x+\theta)}{a_2} = \frac{\cos(x+2\theta)}{a_3} = \frac{\cos(x+3\theta)}{a_4}$

prove $\frac{a_1+a_3}{a_2} = \frac{a_2+a_4}{a_3}$.

50. If $\frac{\sin(\theta-\beta)\cos\alpha}{\sin(\phi-\alpha)\cos\beta} + \frac{\cos(\alpha+\theta)\sin\beta}{\cos(\phi-\theta)\sin\alpha} = 0$

and $\frac{\tan\theta\tan\alpha}{\tan\phi\tan\beta} + \frac{\cos(\alpha-\beta)}{\cos(\alpha+\beta)} = 0$

prove $\tan\theta = \frac{1}{2}(\tan\beta + \cot\alpha)$

and $\tan\phi = \frac{1}{2}(\tan\alpha - \cot\beta)$.

51. Given $\log 4{\cdot}2366 = {\cdot}6270227$, find the value of $(\frac{1}{3})^W$.

52. Show that $\sin 30^\circ\,1' = \cos 1' - \sin 29^\circ\,59'$.

53. If a be a side of a regular polygon of n sides and R, r, the radii of its circumscribed and inscribed circles, show that $R + r = \frac{1}{2}a\cot\frac{\pi}{2n}$.

54. What does the formula in 53 become, if the figure be a triangle.

55. Prove that $\sin 41^\circ + \sin 67^\circ - \sin 31^\circ - \sin 77^\circ = \sin 5^\circ$.

56. If p be the perpendicular from the angle A on the opposite side, show that

$$\frac{a\sin A + b\sin B + c\sin C}{bc\cos A + ca\cos B + ab\cos C} = \frac{2p}{bc}.$$

57. Show that

$$\cot\theta + \cot 2\theta + \cot 4\theta = \operatorname{cosec} 4\theta\,(2 + 2\cos 2\theta + 3\cos 4\theta).$$

58. If the sides of a triangle ABC be divided in D, E, F, so that $\frac{AF}{BF} = \frac{BD}{CD} = \frac{CE}{AE} = \frac{1}{n-1}$ prove that the area of the triangle formed by joining the points of section : area of the original triangle $= n^2 - 3n + 3 : n^2$.

59. The tangents of the angles of a triangle are as the numbers 1, 2, 3 ; find them.

60. If c be the chord of a quadrantal arc, a its radius, and r the radius of the circle inscribed in the quadrant, show that

$$a + r = c.$$

61. Express $\cos m\theta\cos n\theta\cos r\theta$ by the sum of a series of cosines of multiples of θ.

62. If $\tan A + \sin A = m$, and $\tan A - \sin A = n$ eliminate A.

63. Eliminate θ from

$$(a+b)\tan(\theta-\phi) = (a-b)\tan(\theta+\phi)$$
$$a\cos 2\phi + b\cos 2\theta = c.$$

64. Prove that the area of a triangle equals

$$\tfrac{1}{4}(a^2+b^2-c^2)\cot\tfrac{1}{2}(A+B-C).$$

65. Given α, β, γ, the distances from the angles of the point at which the sides of a plane triangle subtend equal angles ; find the side c.

66. Show that the equation

$$\cos(a+x) = \cos a\sin x + \sin b$$

may be reduced to the two equations

$$\cos(\phi+x) = \sin b\sec a\cos\phi,$$

and $\tan\phi = \sin(45^\circ + a)\sec 45^\circ\sec a$.

67. In a plane triangle if $a + b = m$ show that

$$a = m\cos^2\phi,\ b = m\sin^2\phi$$

when ϕ may be found from the equation

$$m\sin 2\phi = \sqrt{(m+c)(m-c)}\sec\frac{C}{2}$$

68. If p, q, r be the lines drawn from the angles of a triangle to bisect the sides, a, b, c respectively, express a side (a) in terms of p, q, r.

69. If a quadrilateral can both have a circle inscribed in it as well as described about it, show that the sums of its opposite sides are equal and that its area $= \sqrt{abcd}$.

70. Show that x cannot be real in the equation

$$\tan^3 x = \tan(x-a)$$

if $\sin a$ be greater than $\frac{1}{3}$.

71. Transform the equation

$$\sqrt{2\sec A} = \tfrac{1}{3}\sqrt[3]{\frac{\cos^2 B}{\sin C}}$$

into the equation between the tabular logarithms of the quantities.

72. If lines be drawn from the angles of a triangle ABC to the centre of the inscribed circle, cutting its circumference in D, E, F, show that the angles of the triangle DEF are respectively $\frac{1}{4}(\pi + A)$, $\frac{1}{4}(\pi + B)$, $\frac{1}{4}(\pi + C)$.

73. The sides a, b, c, of a triangle are as the numbers 4, 5, 6. Show that $\cos B = \cos^2 A$.

74. Employ a subsidiary angle to adapt $\sqrt{a+b} + \sqrt{a-b}$ to logarithmic computation.

75. The perimeter of a triangle is four times its base (c) ; show that if d be the distance of the centre of its inscribed circle from one end of the base, and ϕ the angle it makes with the base, then

$$d(1 + \sin^2\phi) = c\cos\phi.$$

76. If x, y, z, be the lengths of the lines bisecting the angles of a triangle, and terminated by the opposite sides a, b, c, show that

$$(b+c)^2\frac{x^2}{bc} + (c+a)^2\frac{y^2}{ca} + (a+b)^2\frac{z^2}{ab} = (a+b+c)^2.$$

77. If m be any integer prove that

$$\tan\frac{\pi}{4m}\cdot\tan\frac{5\pi}{4m}\tan\frac{9\pi}{4m}\cdots\tan\frac{(4m-3)\pi}{4m} = \pm 1.$$

78. If from one of the angles of a regular polygon of n sides (each side $= a$), lines be drawn to all the other angles, show that their sum is equal to

$$\tfrac{1}{2}a\operatorname{cosec}^2\frac{\pi}{2n}.$$

79. In the formula $\cos\frac{A}{2} - \sin\frac{A}{2} = \pm\sqrt{1-\sin A}$ the ambiguity $\pm$ may be replaced by $(-1)^m$ when m is the greatest integer contained in $\frac{270+A}{360}$, the angle A being expressed in degrees. Prove this.

80. Show how to express $\cos\frac{A}{2^n}$ in terms of cos A, where n is any positive integer.

81. Sum ad infinitum

$$(1 - 3^{-\frac{1}{2}}) - \tfrac{1}{2}(1 - 3^{-\frac{1}{2}}) + \tfrac{1}{3}(1 - 3^{-\frac{1}{2}}) - \&c.$$

82. Adapt the expression $\frac{1}{a + b\cos x}$ to logarithmic computation, a being less than b.

83. The angles of a triangle are as 3, 4, 5: find its area, having given r the radius of its inscribed circle.

84. If from the ends of the base of a semicircle two chords be drawn, crossing each other and making angles α, β, with the base, and if the extremities of these chords be joined, the areas of the two triangles thus formed will be as $\cos^2(\alpha + \beta) : 1$.

85. Prove that

$$\sin\theta \sin\theta - \tfrac{1}{2}\sin 2\theta \sin^2\theta + \tfrac{1}{3}\sin 3\theta \sin^3\theta - \&c. = \cot^{-1}(1 + \cot\theta + \cot^2\theta).$$

86. Find the limits of $\left(\cos\frac{a}{n}\right)^{n^2}$ and $\left(\cos\frac{a}{n}\right)^{n^3}$ when n is increased indefinitely.

87. Show that $\left(\frac{x-1}{x}\right)^x$ continually increases as x increases from unity to infinity; and find the limit of the expression when x is increased indefinitely.

Solve by Trigonometry the following three equations.

88. $8x^3 - 36x^2 + 42x - 13 = 0$.

89. $2x^3 - 3x - 1 = 0$.

90. $x^3 - 3x + 1 = 0$.

91. If two lines at right angles to one another on an inclined stratum, make angles α, β, with the horizontal plane, show that the dip (θ) of the stratum is given by the equation.

$$\cos\theta = \sqrt{\cos(\alpha + \beta)\cos(\alpha - \beta)}.$$

92. In any triangle given the sides b, c, show that if A receive a small increment (α) then B and C will receive small decrements respectively of

$\alpha \sin B \cos C \operatorname{cosec} A$, and $\alpha \sin C \cos B \operatorname{cosec} A$.

93. If $\tan\theta = \frac{b}{a}$ show by Demoivre's theorem that

$$(a + b\sqrt{-1})^{\frac{m}{n}} + (a - b\sqrt{-1})^{\frac{m}{n}} = 2(a^2 + b^2)^{\frac{m}{2n}} \cos\frac{m}{n}\theta.$$

94. Find the sum of n terms of the series

$$\tan^{-1} a + \tan^{-1}\frac{a}{1 + 1.2.a^2} + \tan^{-1}\frac{a}{1 + 2.3a^2} + \&c.$$

95. Sum to n terms the series

$$\sin^2\theta + \sin^2 2\theta + \sin^2 3\theta + \&c.$$

96. Show that

$$x\sin\theta + \frac{x^2}{2}\sin 2\theta + \frac{x^3}{3}\sin 3\theta + \&c. = \tan^{-1}\left(\frac{x\sin\theta}{1 - x\cos\theta}\right).$$

97. Sum to n terms the series

$$\cos A + \cos 3A + \cos 5A \ldots\ldots$$

98. If $\alpha = \frac{\pi}{4n}$ show that

$$\sin\alpha \sin 5\alpha \sin 9\alpha \ldots\ldots \sin(4n - 3)\alpha = 2^{-n}.$$

99. Prove that

$$\sin\theta = \theta\left(1 - \frac{\theta^2}{\pi^2}\right)\left(1 - \frac{\theta^2}{2^2\pi^2}\right)\left(1 - \frac{\theta^2}{3^2\pi^2}\right)\ldots\ldots$$

100. From 99, prove that

$$\pi = 3 \cdot \tfrac{4}{3} \cdot \tfrac{4}{5} \cdot \tfrac{6}{5} \cdot \tfrac{6}{7} \cdot \tfrac{8}{7} \cdot \tfrac{8}{9} \ldots\ldots$$

(To be continued.)

—o—

Quarterly Arithmetical Tests.

STANDARD I.—FIRST QUARTER.

1. 346
   7
   80
   409
   52

2. 675
   420

3. 189
   56

4. 11×2;
   4×3;
   12×4.

SECOND QUARTER.

1. 5
   91
   637
   4
   826

2. 392
   245

3. 708
   513

4. 9×3;
   5×4;
   10×5.

THIRD QUARTER.

1. 73
   549
   8
   960
   15

2. 401
   397

3. 806
   9

4. 8×4;
   7×5;
   6×6.

STANDARD II.—FIRST QUARTER.

1. 5,704
   93
   62,018
   530
   9,675

2. From 67,504 take 58,097.

3. 40,639 × 85.

4. 8×8; 9×9; 11×11.

SECOND QUARTER.

1. 28,076 × 490.
2. From 30,003 subtract 978.
3. 17,034 ÷ 3.
4. 23d.; 49d.; 65d.

THIRD QUARTER.

1. 63,902 ÷ 8.
2. 85,647 × 6,007.
3. Take 49,909 from 50,505.
4. 78d.; 104d.; 142d.

STANDARD III.—FIRST QUARTER.

1. 150,536 ÷ 31.
2. Divide 407,609 by 86.
3. What is the quotient if the dividend be six hundred and fifty-eight thousand and sixty-three and the divisor nine hundred and seven?
4. There are four hundred gallons of water in a cistern. How much would be left after 18 houses had each drawn 17 gallons?

SECOND QUARTER.

1. What is the sum of eighty-seven pounds fifteen shillings and two pence three-farthings, seventeen shillings and nine pence halfpenny, thirty-four pounds eleven shillings and ten pence three-farthings, sixteen shillings and fivepence farthing, and fifty-nine pounds fourteen shillings and eight pence three-farthings?

2. How often is one hundred and thirty-five contained in eight hundred and four thousand six hundred?

3. What is left when £706 15s. 8¾d. is taken from one thousand pounds?

4. A man commences business at 25 years of age and continues until he is 60. He earns £480 per year. How much does he earn altogether?

THIRD QUARTER.

1. What must be added to fifty-eight thousand and forty-nine pounds seventeen shillings and ten pence three-farthings to make sixty thousand and twenty pounds thirteen shillings and eight pence halfpenny?

2. £908 14s. 8½d. + £74 16s. 10d. + £5,009 7s. 6½d. + £381 19s. 11¾d. + £8,263 12s. 7½d. + £92 8s. 9¾d.

3. How often is 4s. 9d. contained in two hundred and thirty thousand nine hundred and sixty-four pence?

4. A man bought 750 oranges for £2 17s. 4d., and sold them at 10 for a shilling. How much did he gain?

STANDARD IV.—FIRST QUARTER.

1. £95 16s. 7¾d. × 81.

2. Find the cost of 17 score sheep at £1 18s. 9d. each.

3. Divide £7,090 13s. 2d. by eight.

4. Find the seven hundred and sixty-ninth part of sixty-nine thousand nine hundred and seventy-four pounds nineteen shillings and ten pence three-farthings.

SECOND QUARTER.

1. Reduce seventeen thousand and nineteen guineas to farthings.

2. How many cwt., &c., are equal to three million five thousand and seventeen half-ounces?

3. Reduce 7 miles to inches and divide by 32.

4. There were 100 coins in a bag, consisting of 26 halfpence, 19 pence, 24 sixpences, 19 shillings, and the rest florins. How much money was in the bag?

THIRD QUARTER.

1. How many more seconds are there in the month of August than in the month of September?

2. Reduce five hundred thousand and eighteen pints of beer to hhds., &c.

3. How many ells, &c., are equal to one million one thousand one hundred inches?

4. A man bought 13 cwt. of potatoes at 3s. 6d. per cwt. and sold them at a halfpenny per pound. How much did he gain?

STANDARD V.—FIRST QUARTER.

1. How much must be given for 142,128 penholders at 1s. 10½d. per gross?

2. Find the cost of 157,580 cwt. at £19 14s. 8½d. per ton.

3. What is the value of 17 cwt. 2 qrs. 22 lbs. at £16 6s. 8d. per ton?

4. What should a brewer receive for 35 hhds. 47 gals. 3 qts. of ale at 3 guineas per hhd.?

SECOND QUARTER.

1. If a hundred pounds gain £7 10s., what will £18 15s. gain?

2. Make out a bill for the following articles:—
102 plates at 5s. 8d. per doz.;
3 gross tea-spoons at 1s. 7d. per doz.;
2 gross table-spoons at 11½d. each;
7 doz. dishes at 9½d. each;
29 basins at 2s. 6d. per doz.

3. Find the cost of 15 cub. ft. 1,080 in. at 1½ guineas per cubic yard.

4. If a pole 5 feet high cast a shadow 6 ft. 4 in. long, how high is a mast which casts a shadow 28½ ft. long?

THIRD QUARTER.

1. A rent-collector, after deducting his commission of 9d. in the pound, paid to his employers £2,358 2s. 6d.; what was the amount of the rents collected?

2. Find the G. C. M. of 5,372 and 4,661.

3. £36 14s. 5⅞d. — £29 16s. 8⅛d.

4. A man sold ⅓ of his flock to one man, and ⅕ to another. He had 75 sheep left. How many had he at first?

STANDARD VI.—FIRST QUARTER.

1. What must be added to the sum of $\frac{9}{10}$, $\frac{5}{14}$, $\frac{7}{15}$, and $\frac{1}{2}\frac{1}{1}$ to make the result an integer?

2. Simplify:— $\dfrac{2\frac{1}{4} \text{ of } \frac{3}{5} - \frac{7}{10} \text{ of } 1\frac{1}{4}}{\frac{9}{11} \text{ of } 3\frac{1}{7} - \frac{5}{14} \text{ of } 1\frac{1}{10}}$.

3. Simplify:—59·37 − 46·8763 + 9·027.

4. $4\cdot65\dot{8} \div 3\cdot025$.

SECOND QUARTER.

1. Reduce $\frac{7}{9}$ of a crown to the fraction of 2 guineas.

2. Find the third term of the proportion:—
153 : 187 :: ( ) : 88.

8. Which is greater, and by how much, ·65 of a guinea or ·6̇5̇ of a pound?

4. If 63 tailors can execute an order for regimental clothing in 40 days, how many more tailors must be engaged to do the work 12 days sooner?

THIRD QUARTER.

1. What is the simple interest on £380 for 4·75 years at 3·25 per cent.?

2. A house worth £3,375 is insured for three-quarters of its value at 2½ per cent. What is the annual premium?

3. Find the amount of £2,286 13s. 4d. for 7¼ years at £2 12s. 6d. per cent.

4. A person had £76 11s. 8d. He gave ⅓ to A., and ¼ of the remainder to B. How much had he left?

STANDARD VII.—FIRST QUARTER.

1. What sum will gain £86 4s. 7½d. in 4½ years at 3½ per cent.?

2. If 15 women earn £66 10s. in 7 weeks, what will 19 women earn in 9 weeks?

3. In what time will £850 amount to £955 3s. 9d. at 5½ per cent.?

4. If 16 men can build a wall 54 yards long in 18 days of 9 hours each, how many hours a day must 30 men work to complete a wall 70 yards long in 14 days?

SECOND QUARTER.

1. What is the true discount on £505 18s. 9d. due in 3 months at 4¾ per cent.?

2. The numbers present during a school week were 186, 145, 179, 163, 200, 192, 174, 189, and 157. What was the average attendance?

3. A bankrupt owes three creditors £145, £278, and £310 respectively; his property is worth £412 6s. 3d. What ought each to receive?

4. If 37 horses cost £908 15s., and 8 of them cost £27 10s., what is the average price of the remainder?

THIRD QUARTER.

1. If a tobacconist buy 2 cwt. of tobacco for £44 16s., what must he sell it at per ounce so as to gain 25 per cent. on his outlay?

2. Find the compound interest on £366 13s. 4d. for 1½ years at 5 per cent., interest payable half-yearly.

3. If 6 per cent. be lost by selling a horse for £23 10s., what would be the percentage of gain if sold for £27?

4. What income would be derived from investing £2,821 10s. in the Four-and-a-Half per Cents. at 106¾, brokerage being ⅛ per cent.?

ANSWERS.

STANDARD I.

	FIRST.	SECOND.	THIRD.
1.	894.	1,563.	1,605.
2.	255.	147.	4.
3.	133.	195.	797.
4.	22; 12; 48.	27; 20; 50.	32; 35; 36.

STANDARD II.

	FIRST.	SECOND.
1.	78,020.	13,757,240.
2.	9,407.	29,025.
3.	3,454,315.	5,674 + 2.
4.	64; 81; 121.	1s. 11d.; 4s. 1d.; 5s. 5d.

THIRD.

1.	7,987 + 6.	3.	596.
2.	51,983,529.	4.	6s. 6d.; 8s. 8d.; 11s. 10d.

STANDARD III.

	FIRST.	SECOND.	THIRD.
1.	4,856.	£183 16s. 1d.	£1,970 15s. 9¾d.
2.	4,739 + 55.	5,960 times.	£14,731 0s. 5¼d.
3.	725 + 488.	£293 4s. 3½d.	4,052 times.
4.	94 gallons.	£16,800.	17s. 8d.

STANDARD IV.—FIRST.

1.	£7,762 8s. 3¾d.	3.	£886 6s. 7½d.
2.	£658 15s.	4.	£90 19s. 10½d.

SECOND.

1.	17,155,152 far.	3.	13,860 inches.
2.	838 cwt. 1 qr. 22 lbs. 12½ oz.	4.	£2 17s. 8d.

THIRD.

1.	86,400 sec.	3.	22.246 ells 3 qrs. 1 nl. ¾ in.
2.	1,157 hhds. 24 gals. 1 qt.	4.	15s. 2d.

STANDARD V.—FIRST.

1.	£92 10s. 7½d.	3.	£14 9s. 0½d.
2.	£155,487 2s. 9¾d.	4.	£113 0s. 8½d.

SECOND.

1. £1 8s. 1½d.
2. £2 8s. 2d. + £2 17s. + £13 16s. + £3 6s. 6d. + 6s. 6½d. = £22 13s. 8½d.
3. 18s. 2¾d.
4. 22½ feet.

THIRD.

1.	£2,450.	3.	£6 17s. 9 3/14d.
2.	79.	4.	450 sheep.

STANDARD VI.

	FIRST.	SECOND.	THIRD.
1.	13/105.	5/21.	£58 13s. 3d.
2.	1 1/18.	72.	£63 5s. 7½d.
3.	21·5207.	'65 guinea by 6 7/8d.	£2,721 16s. 11½d.
4.	1·54.	27 tailors.	£38 5s. 10d.

STANDARD VII.

	FIRST.	SECOND.
1.	£547 10s.	£5 18s. 9d.
2.	£108 6s.	176·1.
3.	2½ years.	£81 11s. 3d., £156 7s. 6d., and £174 7s. 6d.
4.	8 hours.	£23 15s.

THIRD.

1.	3¾d.	3.	8 per cent.
2.	£28 3s. 10⅜d.	4.	£118 16s.

Mental Arithmetic, its Principles and Practice.

BY REV. A. D. CAPEL, M.A.,

Author of 'Catch Questions in Arithmetic,' 'Tips in Algebra,' 'Easy Steps in Trigonometry,' etc., etc.

ANSWERS TO EXERCISES.

CHAPTER XXVII.

1.	616 sq. ft.	17.	24 sq. ft.
2.	201½ sq. ft.	18.	13,455 sq. ft.
3.	63 3/8 sq. ft.	19.	119 sq. ft.
4.	15 11/16 sq. ft.	20.	4,067 sq. in.
5.	9¾ sq. ft.	21.	14½ sq. ft.
6.	154 sq. ft.	22.	4,255 sq. in.
7.	616 sq. ft.	23.	13⅜ sq. ft.
8.	7,546 sq. in.	24.	1 47/80 sq. mile.
9.	½ sq. ft.	25.	162 sq. poles.
10.	½ sq. inch.	26.	1 : 4.
11.	188¼ sq. in.	27.	1 : 2.
12.	51¼ sq. in.	28.	21 ft.
13.	168 sq. yds.	29.	16 ft.
14.	420 sq. yds.	30.	No difference.
15.	8,748 sq. in.	31.	72½ sq. yds.
16.	120 sq. in.	32.	14 yds.

33. $31\frac{1}{4}$ yds.
34. $12\frac{1}{2}$ ft.
35. $15\frac{1}{4}$ sq. ft.
36. $100\frac{1}{4}$ sq. ft.
37. $12\frac{1}{2}$ sq. ft.
38. $14\frac{1}{4}$ sq. ft.
39. 154 sq. ft.
40. $3\frac{1}{2}$ sq. miles.
41. 1 mile 3 furlongs.
42. 1 mile 4 furlongs.
43. 88 : 99·2 : 100.
44. $2\sqrt{110} : 24$.
45. Threefold.
46. 144.
47. 3 : 5.
48. 36, 16, 9.
49. 9 : 16 : 25.
50. $\sqrt{154} : 16$.

CHAPTER XXVIII.

RIGHT-ANGLED TRIANGLES, RHOMBUSES AND EQUILATERAL TRIANGLES, &c.

247. In Euclid I. 47, we learn the well known fact that in a right angle triangle the square on the side opposite the right angle (called the hypotenuse) is equal to the sum of the squares on the two sides containing the right angle.

248. If therefore we know that the triangle is right-angled, and also know the lengths of any two of the sides, we can find that of the third.

249. If we know the hypotenuse and one side we must find the square root of the difference between the squares of the hypotenuse and the side which is given; *e.g.*, if a ladder 13 yds. long touch the wall at a distance of 12 yds. from the base, how far from the wall is the foot of the ladder?

Ans. $\sqrt{13^2 - 12^2}$ yds. $= \sqrt{25 \times 1}$, or 5 yds.

250. In Euclid II. 12 and 13, we learnt the extension of the above in connection with the sides of other than right-angled triangles, but it is only of triangles containing one or two particular angles that we can treat here.

251. The three angles of a triangle contain together 180°, if, therefore, these three angles are equal to each other, which is the case in an equilateral triangle, each of the angles contains 60°; but in an equilateral triangle the perpendicular let fall from the vertex to the base bisects the base; if, therefore, in a triangle we know two sides, and that the angle between them is 60°, we can find both the other side, and the area; *e.g.*, let ABC be a triangle and let the angle B contain 60°, and let AB = 60 in. and BC = 32 in. Drop the perpendicular AD from A on BC, then BD = ½ of 60 or 30. ∴ by Euc. II. 13.

$$\therefore AC = \sqrt{60^2 + 32^2 - 2.30.32}$$
$$= \sqrt{60^2 - 28.32}$$
$$= \sqrt{2704} = 52.$$

252. If the angle between the given sides is 30°, the length of the perpendicular will be half the other side than that to which it is drawn, hence the area can be written down at once; *e.g.*, what is the area of the triangle ABC, if angle B is 30°, AB 4 yards, and BC 10 yards? AD (the perpendicular) is 2 yards, hence the area is $\frac{1}{2}.2.10$, or 10 square yards.

253. If we know the sides of a rhombus and one diameter, we can find the other diameter at once, since half of it is $= \sqrt{\text{side}^2 - (\text{half of given diameter})^2}$ *e.g.*, what is the area of the rhombus of which the sides are each 5 feet, and one diameter 8 feet? The other diameter $= 2\sqrt{5^2 - 4^2} = 6$, ∴ the area $= \frac{1}{2}$ (8 × 6) or 24 sq. feet.

254. Since the length of the perpendicular drawn from the vertex to the base of an equilateral triangle is half the base × $\sqrt{3}$, in finding the area of a triangle containing the angle 60° we shall generally find this quantity $\sqrt{3}$ involved; *e.g.*, the area of triangle in 251 is $480\sqrt{3}$.

255. The diagonal of a square is found by multiplying the side of the square by $\sqrt{2}$. This comes immediately from Euclid I. 47, if we call each side 1; hence the square on the diagonal is double the square on the side.

256. EXAMPLES XXVIII.

In the ten following Triangles find the third side; the angle C being a right angle, and therefore AB the hypotenuse.

1. AB = 13, AC = 5. Find BC.
2. AB = 25, AC = 7. Find BC.
3. AC = 40, BC = 9. Find AB.
4. AB = 61, BC = 11. Find AC.
5. AC = 84, BC = 13. Find AB.
6. AB = 205, BC = 45. Find AC.
7. AB = 305, BC = 55. Find AC.
8. AB = 65, BC = 52. Find AC.
9. BC = 22, AC = 120. Find AB.
10. AC = 21, BC = 72. Find AB.

Find the area of the following triangles. Leaving $\sqrt{2}$ and $\sqrt{3}$ in that form:—

11. B = 30°, AB = 10 ft., BC = 12 ft.
12. B = 30°, BC = 8 ft. 6 in., AB = 9 ft.
13. B = 60°, AB = 8 ft., BC = 5 ft.
14. B = 45°, AB = $2\sqrt{2}$ in., BC = 3 in.
15. B = 45°, AB = 7 in., BC = 11 in.
16. B = 60°, AB = 4 ft. 2 in., BC = 7 ft. 1 in.
17. B = 30°, AB = 5 ft. 3 in., BC = 4 ft. 7 in.
18. B = 45°, AB = BC = 2 ft.
19. B = 30°, AB = BC = 3 ft.
20. AB = BC = CA = 2 ft.

Find the area of the following parallelograms. The two diagonals being AC and BD:—

21. AB = 8 ft., B = 60° and BC = 10 ft.
22. AB = 10 ft., B = 30° and BC = 12 ft.
23. AB = $3\sqrt{3}$ ft., B = 60° and BC = 10 ft.
24. AB = 7 ft., B = 30°, and BC = 5 ft. 6 in.
25. AB = $3\sqrt{2}$ ft, B = 45° and BC = 8 ft. 4 in.
26. AB = BC = $6\sqrt{3}$ ft. and B = 60°.
27. AB = BC = $7\sqrt{2}$ ft. and B = 45°.
28. AB = BC = 1 ft. and BD = AC × $\sqrt{3}$.
29. AB = BC = 3 and BD = 10.
30. AB = BC = 12 and AC = 10.
31. Compare the area of a square and a circle of the same diameter.
32. Show that the semicircles drawn on the two sides of the right-angled triangle (sides 3, 4 and 5) are equal to the semicircle drawn on the hypotenuse.
33. If equilateral triangles be described on the two sides (5 and 12) of the right-angled triangle (5, 12, 13) show that their sum is equal to the equilateral triangle drawn on the hypotenuse.
34. Compare the area of a triangle, each side 1 in.; a circle, diameter 1 in.; and a square, each side 1 in.

What is the length of the perpendicular drawn from A to BC in the six following triangles:—

35. AB = 3 in.; BC = 5 in.; CA = 4 in.
36. AB = 5 in.; BC = 13 in.; CA = 1 ft.
37. AB = 13 ft.; BC = 15 ft.; CA = 14 ft.
38. AB = 1 ft. 1 in.; BC = 2 ft.; CA = 1 ft. 1 in.
39. AB = 55; BC = 305; CA = 300.
40. AB = 22; BC = 122; CA = 120.

41. If the four corners of a material square were hinged together what would be the length of the short diameter if it were compressed into a rhombus containing half the area of the square, each side being 1 in.?

42. How far up a house would a ladder 65 feet long reach if its foot were 25 feet from the base of the house?

43. What is the area of a rhombus whose side is 10 feet and 1 diameter 16 feet?

44. What is the area of a rhombus whose smaller angles are each 30° and sides 3 ft.?

45. What is the area of a rhombus whose smaller angles are each 60° and sides $4\sqrt{3}$ ft.?

46. What is the area of a rhombus whose smaller angles are 45° and sides $3\sqrt{2}$ in.?

47. If a square and a rhombus (smaller angle 30°) have the same perimeter, compare their areas.

48. If a rhombus and an equilateral triangle have the same perimeter of 12 feet, and the smaller angle of the former be 30°, compare their areas.

49. If a rhombus, the smaller angle of which contains 60°, have the same area as an equilateral triangle (each side 2 feet); find the perimeter of the rhombus.

50. Circles are drawn on the two diameters of a rhombus as their diameters; if the smaller angle of the rhombus be 60°, compare the areas of the circles.

CHAPTER XXIX.

DIVIDING NUMBERS IN GIVEN RATIOS, CHANGING UNITS, AND PROBLEMS.

257. If we want to divide a number as 26 so that its two parts may be in the ratio of 5 : 8, we proceed thus. Since $5 + 8 = 13$, as many thirteens as there are in 26, so many fives and eights must we have. $\therefore$ since $\frac{26}{13} = 2$ the answer is 10 : 16, and $10 + 16 = 26$ and $10 : 16 = 5 : 8$.

258. If we want to divide a number as 100 in the ratio of 5 : 7 : 8, we proceed in the same way. Since $5 + 7 + 8 = 20$, as often as 20 is contained in 100, so many fives, and so many sevens, and so many eights must there be; $\therefore$ since $\frac{100}{20} = 5$, the numbers are 25 : 35 : 40.

259. In the expression 25 miles an hour we have two units, one of distance, the other of time. It is manifest we can change either, or both of these, thus: 25 miles an hour is $\frac{25}{60}$ miles a minute, or $\frac{25 \times 1{,}760}{60}$ yards a minute, or $\frac{25 \times 1{,}760}{60 \times 60}$ yards a second, or $\frac{25 \times 1{,}760 \times 3 \times 12}{60 \times 60}$ inches a second. If we are asked how many inches a second are equal to 25 miles an hour, our mental operation is to simplify this last fraction, which becomes the number 440.

260. Similarly, £100 a year is (counting the working day as 12 hours) $\frac{100 \times 20 \times 12 \times 4}{365 \times 12 \times 60}$ farthings a minute, and this reduces to $\frac{100}{219}$, or a little less than half a farthing a minute.

261. At the end of the set of Examples some problems of varied kinds will be found, to perform which hints will, in some cases, be given with the answers.

262. EXAMPLES XXIX.

1.	Divide	112	in the ratio of	3 : 4.
2.	,,	115	,,	4 : 1.
3.	,,	126	,,	5 : 4.
4.	,,	1,001	,,	3 : 8.
5.	,,	10,101	,,	2 : 1.
6.	,,	111	,,	18 : 19.
7.	,,	221	,,	7 : 6.
8.	,,	486	,,	21 : 33.
9.	,,	10,000	,,	12 : 13.
10.	,,	961	,,	14 : 17.
11.	,,	492	,,	1 : 2 : 3.
12.	,,	1,728	,,	3 : 4 : 5.
13.	,,	1,728	,,	11 : 12 : 13.
14.	,,	441	,,	5 : 7 : 9.
15.	,,	351	,,	6 : 9 : 12.
16.	,,	561	,,	7 : 11 : 15.
17.	,,	1,000	,,	1 : 2 : 3 : 4.
18.	,,	196	,,	2 : 3 : 4 : 5.
19.	,,	196	,,	1 : 2 : 4 : 7.
20.	,,	1,120	,,	2 : 7 : 11 : 15.

21. Of a mixture of three articles in the ratio of 1 : 11 : 88, how much is there of the second substance in 200 lbs. of the mixture?

22. Of a mixture of five articles in the ratio of 1 : 3 : 7 : 11 : 23, how much of the last substance is there in 900 lbs. of it?

23. If gunpowder is composed of 15 parts of charcoal, 10 of sulphur, and 75 of nitre, how much nitre is there in 4 tons of gunpowder?

24. If copper coins are composed of 95 parts of copper, 4 of tin and 1 of zinc, how much zinc is there in 10 tons of such coins?

25. A certain kind of brass is compounded of 325 parts of copper, 165 of zinc, 8 of lead, and 2 of tin; how much tin is there in 1 ton of such brass?

26. 66 feet per second, how many miles an hour?

27. 55 feet per second, how many leagues (three miles) a day (12 hours)?

28. 50 miles an hour, how many yards per minute?

29. 36 miles an hour, how many yards a day of 11 hours?

30. 70 miles an hour, how many inches per second?

31. £146 a year, how many farthings a second (12 hours to the day)?

32. Five shillings a score, how many pence a dozen?

33. £112 a ton, how many farthings an ounce?

34. 5s. a ream, what fraction of a farthing a sheet?

35. 9s. a yard, how many farthings a nail?

36. £11 a mile, how many farthings a yard?

37. I buy eggs at 1s. a score and sell them at 1d. each, what profit do I make over 1,000 eggs?

38. I buy eggs at 1d. each and sell them at 2s. a score, what profit do I make over 500 eggs?

39. I buy apples at 3s. a bushel and sell them at 6 a penny, how many must there be in a bushel to double my outlay?

40. What is the difference on an income of £600 of paying an income tax of 2d. in the £ or of 1 per cent.?

41. What is the difference between receiving 5s. quarterly for a £20 share, and 4 per cent. per annum on the same amount?

42. How much better per pound is it to invest in the Five per Cents. at 105 than the Four per Cents. at 96?

43. How much better per pound is it to invest in the Five per Cents. at 110 than in the Four per Cents. at 92?

44. If I buy eggs at four for 3d. how many can I sell for 15d. so as to make 25 per cent.?

45. At what price must I sell sugar per 25 lb. to gain 92 per cent. on what cost me 14s. a cwt.?

46. How many yards must I walk each minute to complete 900 miles in 20 days (12 hours to the day)?

47. How many more inches per second is 30 miles an hour than 820 yards a minute?

48. How much better per lb. is it to sell goods at £14 a cwt. than at one penny an ounce?

49. How much more sulphur is there in a ton of English gunpowder of which the parts are 75 of nitre, 10 of sulphur, and 15 of charcoal than in French gunpowder, in which the parts are 77 of nitre, 9 sulphur, and 14 of charcoal?

50. How much less charcoal is there in a cwt. of French gunpowder than in the same quantity of English? See 49.

(To be continued.)

TAKE CARE OF THE MINUTES.

Moderate. *mf.*

1st TREBLE.
2nd TREBLE.
BASS.
1. Take care of the min - utes; They're price - less you
2. Take care of the min - utes; They come and are
know; Will you val - ue them less, That so quick - ly they go?
gone; Yet in each there's a space, For some good to be done.
KEY D. Moderate. mf.
1st TREBLE.
2nd TREBLE.
BASS.
A.t.
It is but a min - ute,' The tri - fler would say; But the
Our time is a tal - ent, We hold from a - bove; May each
p
f
f.D. p
f
min - utes make hours, And the hours make a day.
hour leave us rich - er, In wis - dom and love.
ff
ff

Model Answers to Certificate Questions, Christmas, 1887.

Female Candidates.

SECOND YEAR.

Arithmetic.

(Two hours and a half allowed for this paper.)

No candidate is permitted to answer more than TEN questions. The *solution* must be given at such length as to be intelligible to the examiner, otherwise the answer will be considered of no value.

1. If one number measures two others, it will measure the sum or difference of any multiples of them. Show, as to a class, using both letters and numbers, the truth of this statement.

If one number measures another, it measures all multiples of that other.

For if 7 measure 28, it must also measure twice 28, or three times 28, or any multiple of 28.

If a measure b, it also measures xb.

For let it be granted that a is contained n times in b, then $b = na$; then $xb = xna$, and contains a xn times.

$\therefore$ a measures xb.

If one number measure two others, it also measures their sum.

Because 6 is a measure of 12 and also of 18, it must also measure 12 + 18, or 30.

If a measure b and c, it measures $b + c$.

For let b contain a m times, then $b = ma$;

And let c contain a n times, then $c = na$;

$\therefore$ $b + c = a \times (m + n)$, or $b + c$ contains a $(m + n)$ times, and is therefore a multiple of a.

If one number measure two others it also measures their difference.

Because 5 measures 40 and 15, it must also measure 40 — 15, or 25.

If a measure b and c, it measures $b - c$, b being the greater.

As before, let $b = ma$, and $c = na$;

$\therefore$ $b - c = a \times (m - n)$, or $b - c$ contains a $(m - n)$ times, and is therefore a multiple of a.

2. Find the least common multiple of 259, 1443, and 273, and explain the process you employ.

259 | 273		259 ÷ 7 = 37;
252 | 259		37) 1443 (39
G.C.M. 7 | 14		111
| 14		333
		333

Having obtained the G.C.M. of two numbers, and then of one of the numbers and the third number, we can resolve the numbers thus:—

$$\left.\begin{aligned} 259 &= 7 \times 37 \\ 1443 &= 37 \times 39 \\ 273 &= 7 \times 39 \end{aligned}\right\}$$

It is therefore evident that the L.C.M.

$= 7 \times 37 \times 39$
$= 1{,}443 \times 7$
$= \underline{10{,}101}$. Ans.

3. Explain the method of pointing in extracting the square root of a given number, and find the square root of 33558849.

If we divide any number into portions by pointing off every second figure, beginning with the unit, the number of the points thus made will show how many figures are contained in the root.

	33'55'88'49 (5793
	25
107	855
	749
1149	10688
	10341
11583	34749
	34749

$\therefore$ Square root = 5,793. Ans.

4. A can reap in 8 days a field which takes B 9 days to reap. They work together at harvest and earn £22 10s. 6d. between them. If they share it in proportion to the work they have respectively done, what should each receive?

Part done by A $= \frac{9}{8+9} = \frac{9}{17}$;

$\therefore$ A's share $= \frac{9}{17}$ of £22 10s. 6d.
$=$ £1 6s. 6d. $\times$ 9
$=$ £11 18s. 6d.;

And B's share $=$ £22 10s. 6d. $-$ £11 18s. 6d.
$=$ £10. 12s.

5. I have one bottle full of brandy and a second half full of water. I fill up the second bottle from the first, shake it, and then pour back into the first bottle till it is full. Again I take the first bottle and pour from it into the second till it is full. What is the proportion of brandy in the second bottle?

After first process, second bottle contains $\frac{1}{2}$ brandy;
„ second „ first „ „ $\frac{1}{2}$ brandy
$+ \frac{1}{2}$ of $\frac{1}{2}$ brandy
$= \frac{3}{4}$ brandy,
and second bottle contains $\frac{1}{4}$ brandy;
After third process, second bottle contains
$\frac{1}{4}$ brandy $+ \frac{1}{2}$ of $\frac{3}{4}$ brandy
$= (\frac{1}{4} + \frac{3}{8})$ brandy
$= \frac{5}{8}$ brandy. Ans.

6. Reduce £2 4s. 7½d. to the decimal of £5; and reduce to their equivalent vulgar fractions ·0148, and 3·07½ × 1·2.

$$\text{Fraction} = \frac{\text{£2 4s. 7½d.}}{\text{£5}}$$
$$= \frac{44\frac{1}{2}\text{s.}}{100\text{s.}}$$
$$\therefore \text{Decimal} = \frac{44{\cdot}625}{100}$$
$$= \underline{{\cdot}44625}. \text{ Ans.}$$

$${\cdot}0148 = \frac{148}{9990} = \frac{4}{270} = \underline{\frac{1}{135}}. \text{ Ans.}$$

$$3{\cdot}07\tfrac{1}{2} \times 1{\cdot}2$$
$$= 3\tfrac{75}{990} \times 1\tfrac{2}{5}$$
$$= 3\tfrac{4}{55} \times \tfrac{11}{9}$$
$$= \frac{169}{55} \times \frac{11}{9}$$
$$= \frac{169}{45}$$
$$= \underline{3\tfrac{34}{45}}. \text{ Ans.}$$

7. If I subtract from any number, *e.g.*, 78579632, the same digits in another order, *e.g.*, 23695787, I am sure to find a remainder consisting of an exact number of nines, and having the sum of its digits a multiple of nine. Show this to be true, and explain the reason why it must be true.

78579632 = (A multiple of 9) + 2
23697587 = (A multiple of 9) + 2
54882045 = (A multiple of 9)

Both the original number and the number formed by the digits placed in another order, and the sum of the digits, give a multiple of 9 with remainder 2.

$\therefore$ Difference and sum of digits of difference give a multiple of 9.

8. How can I divide 5 half-crowns, 6 florins, and 29 sixpences, between two persons so that each person shall have the same amount, and also the same number of coins?

No. of coins for each person $= \frac{5 + 6 + 29}{2} = 20$;

Amount „ „ „ $= \frac{12\text{s. } 6\text{d.} + 12\text{s.} + 14\text{s. } 6\text{d.}}{2}$
$= 19\text{s. } 6\text{d.}$;

It is evident that one must have one more half-crown and florins than the other, but have only the amount of sixpence more.

$\therefore$ One has 1 half-crown, 5 florins, and 14 sixpences = 20 coins = amount of 19s. 6d.;

Other has 4 half-crowns, 1 florin, and 15 sixpences = 20 coins = amount of 19s. 6d.

9. Find the difference between the simple interest on £461 5s. for two years at 4 per cent., and the discount on the same sum due after two years at 4 per cent.

£	s.
461	5
	4
1845	0
	2
£36·90	0
	20
s. 18·00	

£	£	s.	£	
108	: 461	5	:: 8	: Discount.
27		20		2
3	9225			
	1025			
		2		
3	2050			
20	683	4d.		
	£34	3s.	4d.	

Interest = £36 18s. Discount = £34 3s. 4d.

∴ Difference = £36 18s. − £34 3s. 4d.
= £2 14s. 8d. Ans.

10. A ship is worth £9,475. For what sum must it be insured at £5 5s. per £100 in order that the owner, in case of loss, may receive both the value of the ship and the premium paid?

£	£	£	
100			
94¾	: 9475	:: 100	: Sum insured.
4	4		
379	37900		
	100		

= £10,000. Ans.

11. What is the least number which, when divided by 33, leaves 32 remainder, when divided by 37 leaves 36 remainder, and when divided by 43 leaves 42 remainder? Explain the process of working.

32 = 33 − 1
36 = 37 − 1
42 = 43 − 1

It is therefore evident that the required number increased by unity is exactly divisible by 33, 37, and 43.

∴ No. required = L. C. M. of 33, 37, and 43, decreased by unity

= 33 × 37 × 43 − 1
= 52,503 − 1
= 52,502. Ans.

12. Six horses and eight cows cost me £375. I sell them for £446 5s., making a profit of 25 per cent. on the horses, and 10 per cent. on the cows. What was the average cost of each horse and of each cow?

Cost of horses + cost of cows = £375;
But, $\frac{25}{100}$ cost of horses + $\frac{10}{100}$ cost of cows
= £446 5s. − £375,
$\frac{1}{4}$ cost of horses + $\frac{1}{10}$ cost of cows = £71 5s.,
∴ Cost of horses + $\frac{1}{10}$ or $\frac{2}{5}$ cost of cows = £71 5s. × 4
= £285;
∴ Cost of cows − $\frac{2}{5}$ cost of cows = £375 − £285,
$\frac{3}{5}$ cost of cows = £90,
∴ Cost of cows = £90 × $\frac{5}{3}$
= £150;
And cost of horses = £375 − £150 = £225;
∴ Average cost of each horse = £225 ÷ 6 = £37 10s.
,, ,, cow = £150 ÷ 8 = £18 15s. } Ans.

13. What sum will amount to £3,515 4s. in three years at 4 per cent. compound interest?

£
104
4·16
108·16
4·3264
112·4864

£	£	
112·4864	: 3515·2	:: 100 : Principal.

= 1124864)351520000000(3125£.

3374592
1406080
1124864
2812160
2249728
5624320
5624320

∴ Sum = £3,125. Ans.

14. If I sell out Two and-a-Half per Cent. Stock at 93⅛ and buy Three per Cents. at 101¼, and by this transaction increase my income by £11 10s. a year, how much had I in the Two and-a-Half per Cents. at first (allowing for the usual brokerages)?

Income on £100 Stock in 1st case = £2½;
Selling price of ,, ,, = £93;
Income on this when transferred = £3 × $\frac{93}{101\frac{1}{4}}$

124
372
495
135
45

= £2$\frac{45}{90}$;
Increase in income = £2$\frac{45}{90}$ − £2½
= £$\frac{68-45}{90}$
= £$\frac{23}{90}$;

£	£	s.	£	
$\frac{23}{90}$	: 11	10	:: 100	: Amount of stock.

∴ Amount of stock = (11½ × 100 ÷ $\frac{23}{90}$) £

45
= $\left(\frac{23}{2} \times \frac{100}{1} \times \frac{90}{23}\right)$£
= £4,500. Ans.

15. Find the square root of 24·950025, and explain by reference to the principle of involution, the reason of the process you employ.

24·950025(4·995
16
89 | 895
801
989 | 9400
8901
9985 | 49925
49925

∴ Square root = 4·995. Ans.

Reason for the above process.

Since $(4{\cdot}5)^2 = 20{\cdot}25$, therefore 4·5 is the square root of 20·25, and we have to investigate the rule by which 4·5, or 4 + ·5, may be obtained from 20·25.

Now, 20·25 = 16 + 4·25
= 16 + 4 + ·25
= $4^2 + 4 + {\cdot}5^2$
= $4^2 + 2 \times 4 \times {\cdot}5 + {\cdot}5^2$,

where we see that 20·25 is separated into parts in which 4 and ·5, together constituting the square root, or 4·5, are made distinctly apparent.

The process for finding the square root will be as follows:—

$4^2 + 2 \times 4 \times {\cdot}5 + {\cdot}5^2$ (4 + ·5
4^2
2 × 4 + ·5 | 2 × 4 × ·5 + $·5^2$
2 × 4 × ·5 + $·5^2$

This operation is clearly equivalent to the following:—

16 + 4 + ·25(4 + ·5
16
8 + ·5 | 4 + ·25
4 + ·25

And this operation is evidently equivalent to the following:—

20·25(4·5
16
85 | 425
425

This is the mode of operation in the process employed.

Correction to No. 8 (FIRST YEAR).

Or,

		£
No. of sheep	= 19 =	95
,, geese	= 80 =	4
,, pigs = 200 − 99	= 101 =	101
	200 =	£200

Female Candidates.

FIRST YEAR.

Mental Arithmetic.

1. From seven thousand take fifteen hundred and fifteen.
= 7000 − 1515 = 5485.

2. Add five times nineteen to four times sixteen.
= 95 + 64 = 159.

3. Multiply 346 by 84.
= 2422 × 12 = 29064.

4. Divide 37875 by 150.
= 3787·5 ÷ 15 = 252 + 75 remainder, or 252½.

5. Multiply 2s. 7½d. by 5 and reduce the answer to half-pence.
= 63 half-pence × 5 = 315 half-pence.

6. Find the G.C.M. of 154 and 638.
154 = 7 × 22 and 638 = 22 × 29,
∴ G. C. M. = 22.

7. Add together ⅛ of a sovereign, ⅛ of five shillings, and ⅛ of a florin.
= 16s. 8d. + 1s. 10½d. + 1s. 4d. = 19s. 10½d.

8. Find the length of one wall of a square room the area being 576 square feet.
= $\sqrt{576 \text{ sq. ft.}}$ = $\sqrt{64 \text{ sq. yds.}}$ = 8 yds., or 24 ft.

9. Find the fourth term of 36 : 63 :: 20.
= 4 : 7 :: 20 : 4th term = 7 × 5 = 35.

10. Find the interest on £420 10s. for one year at 3 per cent.
= £420 10s. × $\frac{3}{100}$ = £1261 10s. ÷ 100
= £12 12s. 3½d.,
or, ,, = £4 4s. 1½d. × 3
= £12 12s. 3½d.

11. If a book published at 2s. 6d. is sold for 2s. 1d., what should be the cost price of a book published at 19s. 6d.?
= $\frac{21}{30}$ of 19s. 6d. = ⅛ of 19s. 6d.
= 3s. 3d. × 5 = 16s. 3d. Ans.

12. What is the average length in days of a calendar month in 1887?
= 365 ÷ 12 = $30\frac{5}{12}$ days. Ans.

13. Express as decimals of £1, the following sums:—17s., 3s. 6d., £1 15s.
17s. = $\frac{17}{20}$ = ·85£;
3s. 6d. = $\frac{7}{40}$ = ·175£;
£1 15s. = $1\frac{3}{4}$ = 1·75£.

14. A can mow a field in 3½ days, B in 4½ days. If they work together for one day, what fraction of the field will be left unmown?
= 1 − (⅞ + ⅞) = 1 − $\frac{18 + 14}{63}$ or $\frac{(7 + 9) \times 2}{63}$
= 1 − $\frac{32}{63}$ = $\frac{31}{63}$. Ans.

15. What sum must be invested in 3 per cent. Consols at 75 to produce an income of £250?
= £75 × $\frac{250}{3}$ = £25 × 250
= £6,250. Ans.

1. Add together 7906, 83, 15000, and 497.
= 23,486.

2. Multiply 37 by 99.
= 3700 − 37 = 3,663.

3. Divide 4824 by 150.
= 482·4 ÷ 15 = 32 + 24 remainder.

4. How many yards are there in a mile and three quarters?
= 1760 × $1\frac{3}{4}$ = 440 × 7 = 3,080 yards.

5. Find the cost of 36 articles at 11½d. each.
= 36s. − 36 halfpence = £1 16s. − 1s. 6d.
= £1 14s. 6d.

6. A man earns £1 7s. 6d. a week. How much does he earn in a year?
= £52 + ½ of £52 = £52 + ½ of £39
= £52 + £19 10s. = £71 10s.

7. What is the rent of a house for 6½ weeks at £54 a year?
= $\frac{6\frac{1}{2}}{52}$ of £54 = ⅛ of £54 = £6 15s.

8. Find the L. C. M. of 8, 10, 24, and 15.
= L. C. M. of 24 and 15 = 24 × 5 = 120.

9. Find the area of a room of which each side measures 18 feet.
= (6 yds.)² = 36 sq. yds., or 324 sq. ft.

10. Goods bought for 15s. are sold for 17s. 6d. Find the gain per cent.
= $\frac{2s.\ 6d.}{15s.}$ of 100 = ⅙ of 100 = 16⅔ %.

11. Find the simple interest on £277 for 3 years at 4 per cent. per annum.
= £277 × $\frac{12}{100}$ = £3,324 ÷ 100
= £33 4s. 9½d.

12. Express in terms of English money:—£17·35, £1·075, £·925.
£17·35 = £17 7s.
£1·075 = £1 1·5s. = £1 1s. 6d.;
£·925 = 18·5s. = 18s. 6d.

13. What is the share of A and B if you divide £27 6s. between them in the ratio of 9 : 4?
A's share = $\frac{9}{9 + 4}$ of £27 6s. = $\frac{9}{13}$ of £27 6s.
= £2 2s. × 9 = £18 18s.
B's ,, = £2 2s. × 4 = £8 8s.

14. At what price must I sell goods bought for £3 10s. in order to gain 10 per cent.?
= £3 10s. + $\frac{1}{10}$ of £3 10s. = £3 17s.

15. What interest is obtained by investing £200 in 3 per cent. Consols at 80?
= £3 × $\frac{200}{80}$ = £3 × ½ = £7 10s.

Male Candidates.

FIRST AND SECOND YEARS.

Geography.

Continued from 'PRACTICAL TEACHER,' *January, 1888.*

3. Explain the causes of land and sea breezes. Describe briefly the cause and course of the Equatorial current.

(3) In tropical regions the wind near the coast blows from the sea over the land during the day; during the night the wind sets in from the land and blows over the sea. The former is called the *sea breeze* whilst the latter is termed the *land breeze.*

The primary causes of these winds are (1) *The great difference these regions experience in the temperature of the day as compared with that of the night* and (2) the high specific heat of the water compared with that of the neighbouring land.

During the day, under the influence of the tropical sun, the land rises in temperature much more rapidly than the water and, as a consequence, the air over the land becomes hotter and rarer than that over the neighbouring water, and just as the cool air outside a room presses the warmer and lighter air inside up the heated chimney, causing an indraught of air, so the cool and heavy air over the sea presses forward and upward the warmer air over the land, causing a breeze to spring up from the sea. After the sun has set the land rapidly cools, whilst the sea maintains very nearly its day temperature; when the land becomes cooler than the sea the air above it cools down and then begins to push forward and upward the warmer and lighter air over the sea, thus giving rise to the land breeze.

Equatorial Current.—The direction of this current in both the Atlantic and Pacific oceans is from east to west. In the Indian Ocean the current is not so marked in character, except on the south of the Equator and here again its direction is westerly. The cause of these remarkably persistent currents is undoubtedly the existence in these regions of permament winds—*the trade winds*—which blow in the same direction as that in which the currents move.

4. Give some reasons (with brief explanations) why isothermal lines do not coincide with parallels of latitude. Does it follow that two places, which have the same average yearly temperature, have also the same climate?

(4) (1) Isothermals in passing over the great oceans curve away from the Equator. On the other hand they approach the Equator over continental areas. This is due to the water having a much higher specific heat than the materials which make up the land, *i.e.*, the water requires much more heat to raise its temperature than the land requires, and when its temperature is raised it cools much more slowly than the land. Then again the circulation of the water tends to keep the temperature equable, especially when it is remembered that the cold water moves along the ocean floor. A very good example is seen if the course of the Isothermal 40° Fahr. be followed from Nova Scotia, where it coincides with parallel 45° N. lat., over the Atlantic, where it reaches the Arctic circle, and again in passing over Siberia reaches parallel 45° N. lat. In explanation of the course of this particular Isothermal it may be stated that the cold Arctic current which passes southward along the shores of Labrador and Nova Scotia causes it to reach its lowest limit, and the warm surface water of the Gulf Stream causes it to be carried northward to its highest limit, whilst the low temperature of the winter season of Asiatic Russia again lowers its course.

(2) The Isothermal does not indicate the range of temperature to which a place is subject. This range between the summer and winter temperature must be determined before the climate of a place is known, *e.g.*, London and Vienna have the same yearly average but not the same range of climate. London varies from 37° Fahr. in winter to 64° in summer. Vienna on the other hand has a winter temperature of 29° Fahr. and a summer temperature of 70°. Thus Vienna has a more *extreme* climate than London.

5. How ar are the expressions 'temperate flora,' 'tropical auna,' correct: *i.e.*, does identity of latitude with similarity of climate imply agreement in the character of the flora and fauna? Give examples.

(5) The terms are only correct in a limited sense. It is true, for instance, that our temperate flora, our forest trees, our roots and cereals, would not flourish in tropical regions. At the same time, if we examine respectively the flora of temperate regions such as New Zealand, South Australia, Cape Colony, and South America, we shall not find identical flora flourishing in each. We shall find New Zealand rich in *conifers* and *pines*, some of which are not found elsewhere. In South Australia the *eucalyptus* and leafless acacias are characteristic. In South Africa *euphorbiæ*, rising without leaves to a height of 40 ft., and *zamia* are peculiar, and in South America the cinchona (yielding Peruvian bark) is a well-known example quite characteristic of the district.

A remarkable case of identity of latitude with close similarity of climate, not implying agreement in character of flora, is seen when the native plant life of New Zealand in the south temperate zone is compared with that of Britain at its antipodes.

In the case of animal life the modes of locomotion possessed by them give to some species a very wide range, still it by no means follows that throughout the entire tropical belt the same fauna are found. The tiger, lion, camel, and elephant range widely over tropical regions in the old world, but are not found in the new world in the same latitudes. In America the llama and alpaca take the place of the camel, the puma and jaguar that of the lion and tiger, and the tapir that of the elephant.

6. What peculiar commercial natural advantages do the British Isles enjoy? Name two towns in them noted for each of the following manufactures, and the rivers (if any) on which they are respectively situated:—wool, glass, salt, silk, carpets, hosiery, lace, linen.

(6) 1. An insular position, with a coast line abounding in excellent harbours.

2. The almost inexhaustible supply of coal and iron, the trade in which employs a vast population.

3. The temperate climate which enables labour and commerce to continue throughout the entire year.

4. The central position with respect to the land hemisphere.

Towns and Manufactures:

(*a*) *Wool*—Leeds, in Yorkshire, on the *River Aire*; Bradford, in Yorkshire, near the *River Aire*.

(*b*) *Glass*—Bristol, on the *Avon*; St. Helens.

(*c*) *Salt*—Northwich, near the *Weaver*; Nantwich, on the *Weaver*.

(*d*) *Silk*—Nottingham, on the *Trent*; Derby, on the *Derwent*.

(*e*) *Carpets*—Halifax, near the *Calder*; Kidderminster, on the *Stour*.

(*f*) *Hosiery*—Leicester, near the *Soar*; Norwich, on the *Wensum*.

(*g*) *Lace*—Nottingham, on the *Trent*; Honiton.

(*h*) *Linen*—Belfast, on the *Lagan*; Barnsley, on the *Dearne*.

7. Describe the course of the Shannon or of the Trent (naming the chief towns, tributaries, counties).

(7) The Trent has its source in the highland which forms a portion of the southern termination of the Pennine Range. This source is in the north of Staffordshire, at an elevation of about 600 ft. The river flows southward through the Potteries past *Leek*, *Stoke*, and *Stone* to near *Stafford*, where it receives its tributary the Sow. After passing *Rugeley* it forms the boundary between Staffordshire and Derbyshire, and receives in this portion of its course the Tame and the Dove. *Burton* is here the most famous town on its banks. Crossing in an easterly direction the county of Derby it receives the Derwent from the north and the Soar from the south, and then immediately enters Nottinghamshire. In this county *Nottingham* and *Newark* stand near, Gainsborough is in the county of Lincoln. After receiving the *Idle* the Trent enters the Humber near its confluence with the River Ouse.

The total length of the River Trent is about 170 miles, out of which 120 are navigable, and an attempt is now being made to extend its navigation to Burton.

8. Describe the physical features of the west coast of Scotland or the east coast of Ireland.

(8) *General View*—

The coast of Ireland from Fair Head to Carnsore Point resembles in general outline the east coast of both England and Scotland. For the most part it consists of long and slightly curving outlines, varied by rugged promontories in the rare cases in which mountain masses or hilly structures approach the coast, and by wide and often sand-choked estuaries wherever a river of considerable size enters the sea.

Physical Features:

Fair Head in the north is a bold headland 600 ft. high, terminating north-eastward the rugged mountains of Antrim. The coast of Antrim maintains its rocky character into the wide estuary of the Lagan—Belfast Lough.

Strangford Lough is a very large opening with a narrow and dangerous entrance. The south coast of Down is rendered very bold and rocky by the approach of the Mourne Mountains. Two openings, viz., Dundrum Bay and Carlingford Lough, are deep and safe harbours, whilst the bays of Dundalk and Drogheda are wide and shallow.

Howth Head, at the northern entrance to Dublin Bay, rises to above 400 ft. in height. The bay to which Dublin gives its name is a fine open expanse, but, unfortunately, it resembles the two last mentioned in being shallow and having its navigation impeded by sandbanks. Southward from Dublin Bay the coast line is broken by a small river mouth at Wicklow, and by the noble and safe harbour of Wexford. Bray Head and Wicklow Head are the chief headlands; the former attains an elevation of more than 700 ft., and is the boldest promontory along the east coast.

9. Where, on what rivers (if any), and for what noted are:—Adrianople, Belgrade, Bologna, Dundee, Heidelberg, Liège, Londonderry, Orleans, Salisbury?

(9) 1. *Adrianople*, the second city in European Turkey, is situated on the *Maritza*. It is the chief centre of the trade of Roumelia, and exports large amounts of silk, cotton and essences.

2. *Belgrade*, on the *Danube*, is the chief fortress and the capital of the newly constituted kingdom of Servia.

3. *Bologna*, a large town in Northern Italy. It stands on the *River Reno*, has a university, and an extensive trade in silk, glass and fancy wares.

4. *Dundee*, on the *Firth of Tay*, is one of the most rapidly rising centres of industry in Scotland. Its trade is chiefly in Baltic goods and with India. The manufacture of jute into sacking and mats is a principal industry.

5. *Heidelberg*, on the *Neckar*, is an old town famous for its castle and university.

6. *Liège*, on the *Meuse*, in Belgium, has numerous iron foundries, and is in the midst of a rich coal field.

7. *Londonderry*, at the head of *Lough Foyle*, has considerable trade with America, and is famous for its siege, 1689.

8. *Orleans*, on the *Loire*, is a large railway centre, and has also trade in sugar and wine.

9. *Salisbury*, on the *Avon*, is the capital of Wilts. It is one of the oldest cities in England and has a magnificent cathedral. It is also a large market town.

10. Give a short account of Russia or of Spain:—(*a*) How governed; (*b*) character of people; (*c*) chief imports and exports; (*d*) course of one river; (*e*) description of one town.

(10) *Russia*:—(*a*) *How governed*: Russia has an absolute hereditary monarch. The administration of the empire is under the direction of four Councils of State—1. Law. 2. Justice. 3. Religion. 4. War, and Work. These all centre in the cabinet of the Emperor.

(*b*) *Character of the People*: Up to 1861 the greater portion of the inhabitants of Russia were *serfs* and in a state of gross ignorance. They are hard-working and thrifty people, courageous in war, and for the most part loyal to their Czar. About four-fifths of the whole number of inhabitants are Slavs, the remainder are Poles, Finns, and Jews.

(*c*) *Chief imports and exports*: The *imports* are cotton yarn, sugar, wine, silk, worsted goods, and tea. The *exports* are wheat, tallow, hides, leather, hemp, flax. timber, furs, and potash.

(*d*) *Course of the Volga*: The Volga is the longest river in Europe. It rises at a low level in the Valdai Hills, and for nearly one half of its course its direction, with many windings, is easterly. It drains the great corn-growing plain of Russia, and forms the natural highway of the commerce of central Russia. By means of canals its navigation is connected with that of the White Sea, the Black Sea, and the Baltic. The chief tributaries in the upper course are the *Oka* from the south, and the *Kama* from the north; the chief towns are Iver, Yaroslav, and Nijni Novgorod. The lower course of the Volga is through the 'Steppes,' portions of which are barren wastes. The chief towns on this portion of the river are Samara, Saratov, and Astrakhan. Towards the mouth of the river sturgeon fisheries are remunerative. After a total course of about 2,000 miles the river enters the Caspian Sea by many mouths, and forms a delta of considerable size.

(*e*) *Description of Moscow*: Moscow, with over 600,000 inhabitants, is the old capital of Russia, and is still the winter residence of many of the nobility. It is very irregularly built. The most remarkable structure is its famous citadel called the *Kremlin*. This building crowns a hill in the centre of the town, is triangular in shape and a mile round. It has a very imposing appearance when viewed from a distance. Besides the Kremlin are many splendid churches, convents, and schools. Moscow is also a university. Its trade is in woollens, cottons, silks, furs and carpets. Near the town the French defeated the Russians in 1812.

11. Give an account of the rise and progress of San Francisco. What features would chiefly strike a stranger on his walking through its streets?

(11) San Francisco in 1847 was a small town of 800 inhabitants. The discovery of gold in that year led to a great inrush of miners from all parts of the world, and a consequent rapid rise in the population. Added to this the general mineral wealth of the surrounding district of California, together with its agricultural development, have maintained the continuous growth of the community until now the population is nearly a quarter of a million. The construction of the Union Pacific Railway has led to the development of the port, which now trades with China, Honolulu, Japan, and New Zealand. As a result of the sudden influx of peoples from many lands, and the great international trade which has recently been developed, the most striking feature which would impress a visitor would be the variety of nationalities represented by the faces he would meet.

12. Name two towns in the United States near the great lakes, and the chief trade and manufactures of each of them. On what facts is the following remark based?—'Boston is the centre of culture in the United States.'

(12) 1. *Chicago* is situated in the south-west corner of Lake Michigan. It has now a population of more than half a million. It is said to be the greatest grain depôt in the world. Ships laden with corn sail from Chicago to Liverpool without unloading. Chicago has also great pig and timber trades.

2. *Buffalo* is on Lake Erie, and has a population of 150,000. These are largely engaged in the manufacture of iron goods, and in the transport of grain, timber and cattle.

3. *Boston* possesses the finest schools in the entire States. They are on a sufficiently grand scale to impress erroneously those who study American education only as there seen. Besides its magnificent high schools Boston possesses the Harvard University, the chief seat of learning in the United States. Other literary institutions, such as learned societies and valuable libraries, together with the circle of literary life, tend to make Boston 'the centre of culture in the United States.'

Male and Female Candidates.

SECOND YEAR.

School Management.

(*Three hours allowed for this Paper.*)

N.B.—Question 1 (on School Registers) *must not be omitted by any Candidate.* Not more than EIGHT questions may be answered.

SCHOOL REGISTERS.

1. (*a*) What do you mean by the *closing* of a Class Register for a morning or afternoon sitting? What acts of carelessness or irregularity on the part of teachers and scholars should be guarded against on these occasions?

(*b*) What facts should be recorded in the Admission Register, and in what circumstances may a name be removed from it, or be inserted in it a second time?

(*c*) (i.) What exceptions are admitted to the general regulation that in order to receive a grant a public elementary school must be open at least 400 times in the year?

(ii.) Describe a scheme of Attendance Prizes.

(iii.) How would you calculate the attendance for a Government Examination held at (1) an interval of seven months from the last inspection; (2) at an interval of fifteen months?

(1) This question was set for Candidates of the First Year who were not proceeding to a Second Year's training. The answer was given in last month's PRACTICAL TEACHER. See Answers to School Management—First Year.

2. Distinguish between analytical and synthetical teaching. Which of these methods is generally better suited for object lessons, and why? Give a short sketch of an analytical lesson on 'Glaciers' for Standards VI. and VII.

(2) *Analytical teaching* is a term applied to that process of training in which we begin with a number of examples; and after a close inspection we see wherein these examples agree and differ, and thus by a process of analysis we are able to determine the general principle or rule they illustrate, or which underlies them.

Synthetical teaching, on the other hand, is employed when we reason deductively as in Euclid. Here we proceed synthetically by combining elementary facts and principles, and so drawing new truths by means of the combination. The analytical method is preferable in object lessons for the following reasons:—

1. The objects are present, and a close inspection will enable the pupil to discover the common principle underlying them.

2. The effort of the pupil thus to proceed from the consideration of concrete cases to the establishment of abstract truth is an excellent mental discipline.

3. The truths thus arrived at are far more likely to be remembered than if they had been communicated by the teacher as mere pieces of information.

Lesson on Glaciers:—

1. *A snow flake*—composed of many snow crystals clinging to each other. These flakes are largest during a *sleet*. Seek for explanation in next example.

2. *A snow ball*—like a snow flake, made out of many snow crystals firmly crushed together. When are these made most easily? Thus connect the temperature (at or near freezing point) with the readiness with which the particles join together.

3. If the class be sufficiently informed on the effect of pressure upon *boiling point* and *freezing point* of water, the 'Theory of Regelation' may be introduced here.

4. Show picture of snow-capped mountains and work out the state which the snow accumulating under great pressure will soon take. (Recall the making of snow ball.)

5. State facts concerning the movements of this consolidated snow in the valleys: (*a*) faster in the middle than sides; (*b*) faster on the top than beneath; (*c*) moves rapidly in narrow valleys and slowly in the wide valleys.

6. Apply the theory of regelation to account for the constant breaking up of the entire mass (due to the above irregular movements) and to explain why the mass maintains its continuity.

N.B.—This would be sufficient matter for two lessons. It is almost impossible to make any lesson entirely analytical. The application of the truths taught by examining the snowflake and snowball to the explanation of the theory of glacial consolidation, movement, and continuity is deductive teaching.

7. The definition of a glacier should be the last step in the lesson.

3. Explain each of these technical terms, and give an illustration of its use:—Syllogism, Inference, Fallacy, Proof.

(3) If I make the following statements:

All animals want food.
Oysters are animals;
Therefore, oysters want food.

I here use three propositions. The first two are termed the *premises* because they are put first to be reasoned about. The last is the *conclusion*, and sets out the result of the reasoning. Whenever our reasoning takes the form thus shown, that form is called a *Syllogism*.

The syllogism is one form in which we set out an argument. We may *infer*, however, without following the syllogistic form. *e.g.*, 'Oysters are animals.' This statement involves the truth of another, viz., 'Some animals are oysters.' In this case two propositions only are concerned. The first is the one with which we set out, the second is inferred. We distinguish between these two forms of inference by stating that the syllogism is a form of '*Mediate inference*,' whilst the shorter mode is termed '*Immediate inference*.' So that the word inference has a wider meaning than syllogism. *We infer, whenever we pass from the truth or falsity of one or more statements to establish the truth or falsity of a new statement whether this be done deductively or inductively.*

Fallacy.—Errors and mistakes in reasoning are termed fallacies. If, for example, we notice at two successive new moons that there has been a change in the weather, and from this limited experience say to a neighbour, that 'to-morrow there will be a change in the weather, for it is new moon,' our reasoning would be fallacious. For the weather changes sometimes two or three times per week, and it is likely therefore that sometimes it will change at new moon, but that does not warrant me in concluding that because it is new moon therefore the weather will change.

Proof, or verification, is the fourth step in inductive reasoning. After experiment, hypothesis, and deductive reasoning, comes verification. Newton applied his theory of gravitation to the movements of the moon round the earth. The result was satisfactory. He then proceeded to show that if his theory of gravitation were true the planets would move round as they do. When, however, the theory was applied to determine the position of a planet which as yet was not known except by the disturbing influence it exerted on the movements of other bodies, then, with the discovery of Uranus, the theory became a well verified hypothesis.

4. What do you understand by a perfect *definition*, and what processes of thought are concerned in arriving at one? Give some examples of definition which are (1) too wide; (2) too narrow; and (3) absolutely exact.

(4) A perfect definition must give the briefest possible statement of such qualities as are sufficient to distinguish the class named from other classes. It should fulfil the following conditions:—

1. State the essential attributes of the species defined.
2. Must not contain the name defined.
3. Must exactly cover the entire group of objects named, and no more.
4. Must not be expressed in obscure, figurative or ambiguous language.
5. Must not be negative where it can be affirmative.

The processes of thought concerned in arriving at a definition, are those exercised in forming a 'concept.'

There must *first* be the consideration of a class. This involves the simple operation of recognizing *differences* and identifying *similarities*. This latter operation of intellect is of prime importance in any attempt at classification, as the class is formed on the basis of the common qualities possessed by the group.

Secondly, thought is exercised in isolating the common features of the class from those features which are not general. This intellectual operation is termed *abstraction*. The further operation of *generalization* is required for the formation of the idea of a general class on the ground of these common qualities. The *name* and *definition* serve to register and symbolize the results of the whole of the previous intellectual operations.

Definitions:—

1. *Too wide.*—An adjective is a word which qualifies. This would include some adverbs.

2. *Too narrow.*—An adjective is a word which qualifies a noun. This would exclude the adjectives which *limit* but do not qualify.

3. *Absolutely exact.*—A triangle is a rectilineal figure having three sides.

5. Criticise the following questions as introductory to collective lessons. Say whether you consider them skilful or unskilful, and why? (1) Why is coal growing scarcer? (2) What animal is most like a dog? (3) Is the tail of the bird in this picture long or short? (4) You are fond of flowers, are you not? (5) What Monarch reigned before Queen Elizabeth?

(1) This question is unskilful because it involves the suggestion of what is not true. There is as plentiful a supply for ordinary use to-day as there was ten years ago, as shown by the price; in fact the price indicates a more plentiful supply.

(2) This is a fair question, inasmuch as it points to a definite answer, viz., the wolf.

(3) If the bird, whose picture is exhibited, possesses a long tail like the *peacock*, or a short tail like the *kingfisher*, the question would be a good one, because it would exercise the judgment of the children in deciding between the tail exhibited and their notion of a fair average length of tail.

(4) This question is decidedly bad. It allows no room for independent thought on the part of the children, moreover the reply must be 'yes,' and answers consisting of single words form a poor exercise in speech.

(5) This is also a faulty question. There are so many answers that the children would be puzzled to know which to select.

6. Discuss these sayings of Friedrich Fröebel; and give them, if you can, a practical application to the work of an elementary teacher:—

(*a*) 'In these games, I detected the main-spring of the moral strength that animated the pupils.'

(*b*) 'Closely akin to the games in their morally strengthening aspect were the walks . . . especially when conducted by Pestalozzi himself.'

(*a*) Fröebel instituted games for his children but was greatly irritated by those who saw in them only games. He had in view, through the delightful employment of children, the skilful development of the entire nature—mental, moral, and physical.

So far as the *moral* nature was concerned, there was first the aroused and directed *attention* of his young pupils. This power of concentration during the exercise of each and all of the intellectual powers lay at the basis of all diligent and successful effort. Then again, he was constant in insisting upon *goodness* in action. Each child was supplied with its own place, and its own materials, so that a feeling of ownership and responsibility was awakened. At the same time the games demanded the exhibition of *obedience* to the commands of the director; of *neatness* and *order* in the arrangement and safe custody of the material; and of *generosity* in sharing them at times with others.

Pestalozzi, whilst at the orphan asylum at Stanz, worked and walked with his pupils during the day, and taught them in the early morning and evening. During their occupation and walks

their observation of nature was directed, and a deep interest in it aroused. Truth, beauty, order, kindness, patience, all these moral qualities were inculcated. Pestalozzi himself says that 'his children *willed*, they had *power*, they *persevered*, they *succeeded*, and they were *happy*.'

The practical teacher in these days finds how invaluable are the moral qualities which both Fröebel and Pestalozzi cultivated and prized. These reformers made high moral qualities the chief aim of their toil, and the best teachers of to-day, whilst compelled to secure certain intellectual results, make it their prime duty to secure through the intellectual acquisitions the moral development of their pupils. Diligence, truthfulness, obedience, a high sense of duty, self-control, a love of the beautiful and the true, all these may be cultivated through the work of the codes if only the teacher be faithful to his high trust, and not the slave to mere intellectual results.

7. How much time per week should be given to each of the elementary subjects, and to sewing, singing, geography, and English respectively, in a mixed school where instruction in music is given by note?

(7) The time would be variously distributed amongst the subjects named, according to the Standard selected, *e.g.*, in Standard I. much more time should be given to reading (as an art), to writing, and to spelling, than in Standard VI., whilst the study of geography and English respectively, would demand more time in Standard VI. than in the lower standards. In order, therefore, to answer the question with precision, one standard may be selected, say Standard IV., and here, supposing the class to have passed a good examination throughout the entire range of subjects the previous year, the following distribution of time should be made:—Reading, 3 hours; writing (including dictation), 3 hours; arithmetic, 5 hours; sewing, 5 hours; geography, 2 hours; English, 2 hours; singing, 1 hour, with practice during intervals of lessons, marching, and during devotional and dismission exercises. This would leave 1 hour per day for Bible instruction, registers, play, and home-work examination, and 1½ hours per week for drawing.

8. In what circumstances is it advisable to teach all the classes the same subjects at the same hours? In what order should you propose to teach reading, writing and arithmetic during the day, and why?

(8) In small schools where the head teacher has most of the teaching to do, there are several subjects he can teach best to the whole school at the same time, *e.g.*, (1) Bible lesson; (2) singing; (3) writing, draft-reading, and spelling; and (4) sewing (for the girls).

N.B.—Whilst under the circumstances this arrangement is best, it is not a good arrangement by any means.

Again, there are some subjects in a large and completely staffed school which may require the synchronous mode of teaching. Arithmetic, for example, may require a re-classification of the school (unless indeed all in every class are unwisely required to march abreast in every subject). When such re-arrangement of classes is deemed advisable, the whole school should take the subject requiring this treatment at the same time.

I should arrange the arithmetic and the reading lesson as far as possible *in the morning*, and the writing lesson *in the afternoon*, for the sufficient reason that both arithmetic and reading require a greater concentration of mind and the co-operation of the higher mental powers; whereas, writing being largely a manual and imitative art, requires less thought and lower mental effort.

9. How far can the teaching of English grammar be made to bear practically upon the oral answering and written exercises of scholars?

In two ways—1st. By the exercise of oral and written language which the study affords, *e.g.*, (*a*) In the oral lessons given by the teacher the children will be encouraged to answer, and their answers should be complete sentences as far as possible. (*b*) The examples supplied by the teacher and subjected to inspection and criticism by the pupils, should be models of 'sentence forming,' and the children should be stimulated to formulate similar examples. (*c*) The written exercise after the oral lesson again should supply the opportunity for cultivating a good style of expression.

2nd. The knowledge which the study of the laws of grammar supplies will have a good effect in enabling the scholar to use his language logically and with grammatical precision, and he will further have at disposal the means of correcting erroneous modes of speech.

10. It is more difficult to secure good *tone* in a day school than in a boarding school. Why? In what way, whether by precept or example, may a right tone be best maintained in an elementary school?

(10) 1. The difficulty of securing a good tone in a day school arises chiefly from the fact that the pupil is under the power of other influence than the teacher's during the greater part of his time. Then again there are more children to manage in the day school, and hence the teacher's influence is less personal and direct than in the boarding school. Further, there is the contamination which always follows the connection with evil. In the elementary day school a bad boy, who is not hopelessly incorrigible, *must* be trained, and the process is often detrimental to the others. In the boarding school such boys are rarely admitted, and, if admitted, the forces available for influencing conduct are more numerous and much more powerful.

2. Example is a most powerful stimulus to right conduct. The teacher's example will be powerful, and indeed will be all-important in initiating and maintaining a good *tone* in his school. The power of the teacher's manner will however be very largely assisted by that which he gradually develops in his pupils. This in time will come to be of greater value in affecting the tone of his school than the power of the teacher's own example. Only a very bad boy indeed will manifest his evil nature in the midst of a community animated and directed by a high tone.

11. Write out a pattern sketch of a lesson on one of these subjects:—

(*a*) Early hours.
(*b*) Digestion.
(*c*) The need of law and of obedience, (*a*) in the school, and (*b*) in the home.

(11) LESSON ON LAW AND OBEDIENCE.

A. *In the School*:—

1. Picture a school in which everyone does as he pleases and whenever he wishes; show how each would be unhappy and none successful. Thus show:

2. *Need for rules in order*:—
(*a*) to secure work suited to all;
(*b*) to secure sufficient supervision and direction;
(*c*) to enable the teacher to know how each department is progressing;
(*d*) to enable him to correct faults and to strengthen whatever he found to be weak;
(*e*) Above all to train to those habits of order and application necessary for successful effort on the part of his pupils after school days are over.

3. *Rules are of no use unless obeyed. Obtain obedience*:—
(*a*) by the reasonable character of the rules;
(*b*) by encouraging pupils to obey the rules;
(*c*) by fear of punishment following disobedience.

B. *In the Home*:—

1. Picture a disorderly home.
2. Rules in the home necessary in order to secure:—
(*a*) health and cleanliness;
(*b*) comfort and rest;
(*c*) happiness and cheerfulness of disposition;
(*d*) love of the various members of the family for one another.
3. Obedience to rules may be secured by the same means as those stated for schools above.

12. In what various ways may children be rewarded for good conduct and proficiency in their studies? Say what kinds of reward appear to you to be most legitimate, and what kinds are open to objection.

(12) 1. By the esteem in which their conduct and proficiency is held by the teacher.

2. By offices of trust (if above Standard IV.), and by marks and prizes (if below Standard IV.)

The nature of the reward for good work and conduct would depend upon the class with which I had to deal. If, for instance, I was dealing with a Standard II. scholar I should allow rewards to take the nature of marks and prizes. Gradually, however, I should withdraw these incentives to effort, and allow the pleasure arising from success, or from the apparent delight manifested by the teacher, or the sense of duty successfully performed, to take the place of the early and adventitious aids to effort. The kind of reward therefore which I deem legitimate for the upper standards would tend to self-directed and independent effort awakened largely by a sense of duty, and the

pleasure which both success and knowledge afford. If *prizes* and *marks* are prolonged to the later school period they become objectionable as tending to weaken self-control and independent effort. *Emulation* and *place taking* foster *self-esteem* on the part of the successful, and *envy* on the part of the backward.

13. Give the dimensions of a school-room capable of accommodating 100 children comfortably. How should you propose to heat and ventilate it?

(13) 1. A main schoolroom, 40 ft. by 20 ft., and a class room, 18 ft. by 20 ft.

2. I should arrange desks along one side of the large room, and across the end of the class room. This would allow all the doors and fireplaces to occupy the opposite side of each room.

3. For warming such a school the open fire would be necessary. I would, however, utilise it as much as possible by having it arranged on the Galton or Manchester principle, so that the back of the fireplace should be a chamber for heating fresh air to be afterwards let into the room from over the mantel-shelf. By this means both warmth and ventilation are secured, as the fire will not only cause warm fresh air to pass into the room, but will cause a circulation of air by withdrawing air from the room up the flue.

For purposes of summer ventilation, and to remedy any defects of the Galton grate in supplying sufficient fresh air in winter, the windows should open on the sash principle, with flaps near the opening to direct the air upwards.

14. How far was Fröebel indebted to Pestalozzi, and in what respects did he improve upon his teaching?

(14) Fröebel was for two years connected with the institute over which Pestalozzi presided at Yverdun, and there he became directly acquainted with the methods of his predecessor. For some years Fröebel continued to apply the Pestalozzian methods in teaching. So far as at present clear, both educationists were enthusiasts in basing all early instruction upon sense knowledge. Pestalozzi put the principle into practice in a vague and random way, whilst Fröebel, by his kindergarten gifts and occupations, placed the principle on a tangible and scientific foundation.

Male and Female Candidates.

FIRST YEAR.

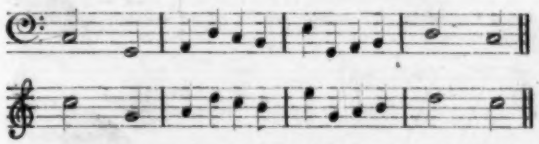
Music.

(*Two hours allowed for this Paper.*)

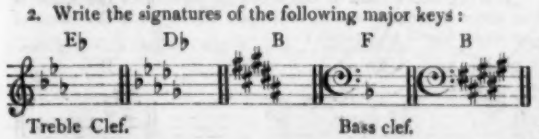
Candidates may answer the questions in either the Staff Notation or the Tonic Sol-fa, but *not both*. The questions in the Tonic Sol-fa notation will be found at the end. You are not permitted to answer more than NINE questions.

STAFF NOTATION.

1. Write the following passage *two* octaves higher in the treble clef:

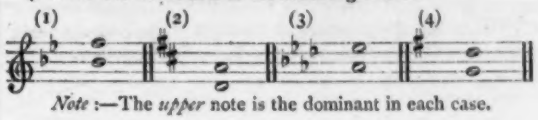


2. Write the signatures of the following major keys:



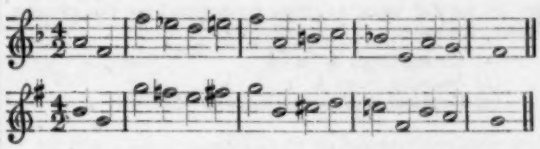
3. Write under each of the following intervals its name (*e.g.*, major sixth, &c.):

4. Write the dominants of the following tonics:

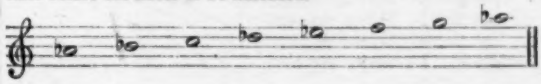


Note:—The *upper* note is the dominant in each case.

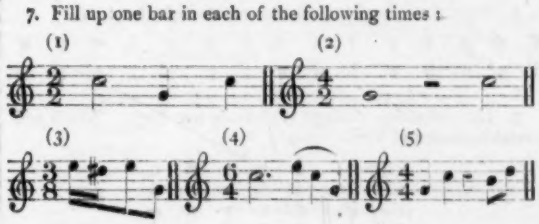
5. Transpose the following a major second higher, namely, into the key of G.



6. Write the scale of A♭ major, placing the necessary flats before the notes to be flattened.

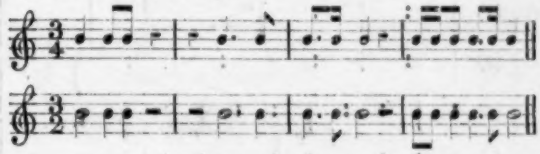


7. Fill up one bar in each of the following times:

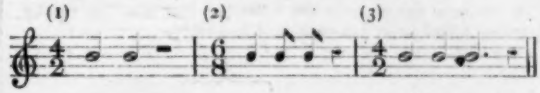


8. Bar the following passages in accordance with the time signatures:

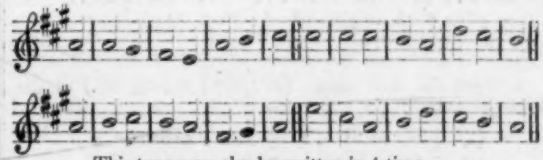
9. Transcribe the following from $\frac{3}{4}$ into $\frac{3}{2}$ time, doubling the value of each note and rest:



10. Add one rest to the end of each of the following to complete the measure in accordance with the signature:



11. Bar the 'Old Hundredth' Psalm tune.



This tune may also be written in $\frac{4}{2}$ time.

12. State the meanings of the following terms:

(1) Crescendo. Gradually louder.
(2) Allegro. Quick, lively time.
(3) Accellerando. Gradually quicker.
(4) ♩ = M. 90. 90 crotchets per minute by the metronome.

TONIC SOL-FA NOTATION.

1. Write down the names of the tones of the common scale in the order they are taught on the Tonic Sol-fa method.

1st Step.—d r m
2nd Step.—t r
3rd Step.—f l

2. State the names of (1) the strong tones of the scale, (2) the leaning tones, (3) those tones that have the greatest leaning tendency.

(1) Strong tones d r m
(2) Leaning tones t, r f l
(3) Greatest leaning tendency t f

3. Name (as major sixth, &c.) the following intervals:

(1) f l Major third.
(2) r s Perfect fourth.
(3) t_1 l Minor seventh.
(4) t_1 d Minor second.
(5) d l Major sixth.

4. Write the following passage an octave higher:

d s_1 m t_1 r l_1 d s_1 f m r l_1 m r d
d^1 s m^1 t r^1 l d^1 s f^1 m^1 r^1 l m^1 r^1 d^1

5. The following passage is given in five keys. Which will sound highest and which lowest?

Key F. d t_1 r m d
Key D. d t_1 r m d
Key E. d t_1 r m d
Key B. d t_1 r m d
Key A. d t_1 r m d

(1) Highest. Key B.
(2) Lowest. Key D.

6. In the major scale (1) which tone is mediant, (2) which supertonic, (3) which sub-dominant, (4) and which leading note?

(1) *Me.* (2) *Ray.* (3) *Fah.* (4) *Te.*

7. Write the pulse signs for—(1) Two-pulse measure. (2) Four-pulse measure. (3) Three-pulse measure. (4) Six-pulse measure.

(1) | : | : } &c.
(2) | : | : | : | : } &c.
(3) : | : : | : : | : } &c.
(4) | : : | : : | : : } &c.

8. Write in figures over the following the value (as 1 pulse, ½ pulse, 1 and ½, &c.) of each note and rest:

2
¾ ¼ ½ ½ 1 1½ ½ + 1 + ½ ½ ¾ ¼ 1
|m .s:f .l :s |m :- . : | .s :f .m:r }
¼ ¼ ½ ½ ½ 1
|s,l . s :l .d :s ||

9. Write the time names (as *taa*, or *taa-tai*, &c.) of the following pulses:

(1) | 1 :1 .1 || *taa : taa-tai.*
(2) | 1 : || *taa : saa.*
(3) | 1 :— || *taa-aa.*
(4) | 1 :- .1 || *taa-aa-tai.*
(5) | 1 .,1 :1 .1,1 || *taa-(e)-fe : taa-tefe.*
(6) | 1.1 . 1 :1 || *tafa-tai : taa.*

10. Re-write the following, doubling the value of each note and rest:

|d . t_1 :d .,r |m : |l :- .s |s,f.m :f .m }
|r .r,m:f . t_1 |d :— ||

|d :t_1 |d :- .r |m :— | : |l :— |— :s }
|s.f:m |f :m |r :r.m |f :t_1 |d :— |— :— ||

11. Add pulse signs proper for the 'Old Hundredth' Psalm tune.

{ :d | d : t_1 | l_1 : s_1 | d : r | m ||
{ :m | m : m | r : d | f : m | r ||
{ :d | r : m | r : d | l_1 : t_1 | d ||
{ :s | m : d | r : f | m : r | d ||

12. State the meanings of the following terms:

(1) Crescendo. Gradually louder.
(2) Allegro. Quick, lively time.
(3) Accellerando. Gradually Quicker.
(4) M. 90. 90 beats per minute by the metronome.

Male and Female Candidates.

SECOND YEAR.

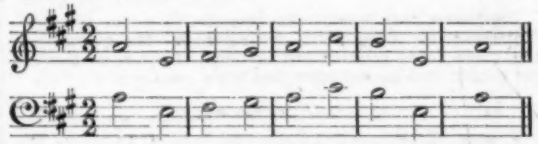
Music.

(*Two hours allowed for this Paper.*)

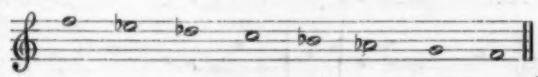
Candidates may answer the questions in either the Staff Notation or the Tonic Sol-fa but *not both*. The questions in the Tonic Sol-fa notation will be found at the end. You are not permitted to answer more than NINE questions.

STAFF NOTATION.

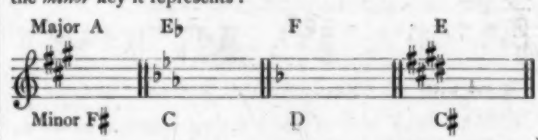
1. Write the following in the bass clef (adding the key signature) one octave lower:



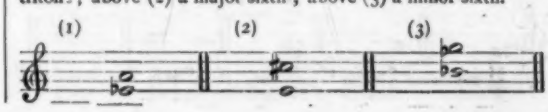
2. Add flats to such notes in the following scale as will make it into the scale of F minor, with a minor seventh and minor sixth:



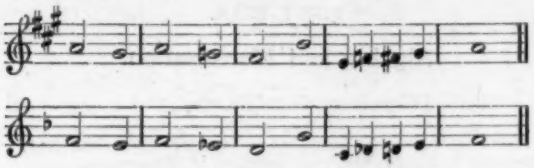
3. Write above each of the following signatures the name of the *major* key it represents, and write below each the name of the *minor* key it represents:



4. Write above (1) an augmented (pluperfect) fourth, or triton; above (2) a major sixth; above (3) a minor sixth.



5. Transpose the following a major third lower, *i.e.*, from A major to F major :



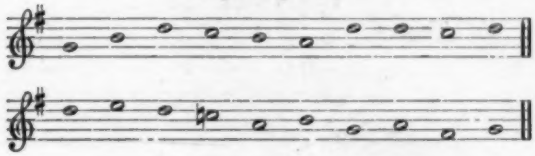
6. Note tests for Division IV. in schools consist of—

(*a*) A simple passage, in a major key, containing a modulation into the key of the fifth above (by raising the fourth degree), or the key of the fifth below (by flattening the seventh degree) ; and

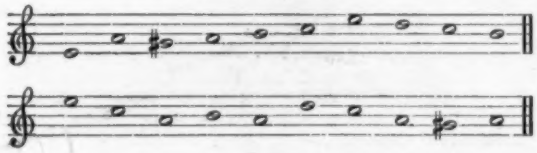
(*b*) A short passage in the key of A minor, introducing the sharpened seventh approached from and leading to the note A, but without introducing the sixth (major or minor) of the scale.

Write two passages (one in G major and one in A minor) of not more than twenty notes each, in accordance with these tests. Write a semibreve for each note, and do not add bars.

Major Key Test.

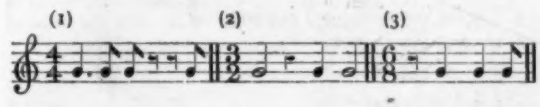


Minor Key Test.



7. Write out the melody of 'God Save the Queen,' in the Key of A, and with a crotchet for a beat or pulse.

8. Complete each of the following bars by adding one note at the end :

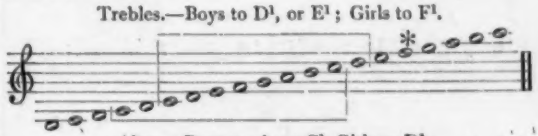


9. Re-write the following passage in $\frac{6}{8}$ time, doubling the value of every note and rest :

10. Place crosses against notes in the following to show the average compass of the voices of children from eight to ten years of age. Say whether your statement refers to Boys *or* Girls.

At this early age the voices are unsettled, and there is not that marked difference between trebles and altos which afterwards exists.

Trebles.—Boys to D^1, or E^1 ; Girls to F^1.



Altos.—Boys to about C^1, Girls to D^1.

11. If you were an adjudicator at a competition of school choirs, under what heads would you give marks?

Maximum 100		
	(1) Good attack, especially at the beginning	10
	(2) Singing sweetly (*i.e.*, without shouting)	10
	(3) Singing in time, parts well together	5
	(4) Singing in tune	10
	(5) Watching the Conductor	5
	(6) Good attention to breathing places	10
	(7) Pronunciation of words	10
	(8) Sustaining the pitch throughout	20
	(9) Expression	20

12. State the meanings of the following terms :

(1) Forte.	Loud.
(2) Presto.	Very quick time.
(3) Dolce	Sweetly.
(4) 𝅗𝅥 = M. 70.	70 minims per minute according to the Metronome.

TONIC SOL-FA NOTATION.

1. The tones $l_1\ d\ t_1\ l_1$ are the relative minor for *d m r d* of the major key. What tones in the relative minor correspond to the following passage in the major ?

Major : d m r s f d m r f s m s_1 l_1 t_1 d

Relative minor : l_1 d t_1 m r l_1 d t_1 r m d m$_1$ { ba_1 or f_1 } se_1 l_1

2. Write he following intervals :

(*a*) Above *doh* an augmented (pluperfect) fourth or tritone. { fe / d }

(*b*) Above *me* a major sixth. { do^1 / m }

(*c*) Above *doh* a minor sixth. { la / d }

3. What is the name (*a*) for *doh* sharp, (*b*) for *lah* flat, (*c*) for *fah* sharp ? (*d*) Re-write the following on the 'imperfect' method (*i.e.*, without change of key).

Doh is C.			f.F.					C.t.		
d	m	r	^fd	m	f	t_1	r	$^m l$	t	d^1

(*a*) de
(*b*) la
(*c*) fe
(*d*) d m r f l ta m s l t d^1

4. Re-write the following in the 'first sharp' key (*i.e.*, regard the first note as *ray*, and so on).

l fe r s fe d^1 t l s fe m ro m
r t_1 s_1 d t_1 f m r d t_1 l_1 se_1 l^1

5. Re-write the following, doubling the value of each note and rest (*i.e.*, write in two pulses what is here given in one pulse) :

s :- .s,f	m .,r :d .t_1	d .r :m	r,m.f :m .	
s :—	— :s .f	m :- .r	d :t_1)
d :r	m :—	r .m :f	m :	

6. What measures are shown by the following?

(*a*) | .s : l .,t | s :-.f | m.,f : s | d :— }

Four-pulse.

(*b*) :s | m.,f : r :s | — : l .,t : d¹ | t :m }

Three-pulse.

(*c*) | m :-.f : s | l :-.s : f | m :— : r | d :— :— }

Six-pulse.

7. Note tests for Division IV. in schools consist of—

(*a*) A simple passage in the major key containing a transition of one remove indicated by bridge notes; and

(*b*) A short passage in the minor key or mode, introducing *se* used thus *l se l*, but without introducing *f* or *ba*.

Write two passages of not more than twenty notes each (without time) in accordance with these tests.

(*a*) d r m f l s ˢd¹ t d¹ r¹ t d¹ ⁴s f m r d f t, d

(*b*) m r m d t, l, se, l, t, d m r d r m l, t, l, se, l,

8. Write the time and tune of the melody of 'God Save the Queen.'

Key **A**.

{ | d :d :r | t, :-.d :r | m :m :f }

| m :-.r :d | r :d :t, | d :— :— ‖

| s :s :s | s :-.f :m | f :f :f }

| f :-.m :r | m :f.m :r.d | m :-.f :s }

| l .s.f :m :r | d :— :— ‖

9. Transcribe the following passage into two-pulse measure (*i.e.* write in one pulse what is here in three pulses):

{ | s :—:— | s :—:s | l :—:d¹ | s :—:— | : : | r¹ :—:— }

| d¹ :m :f | s :l :s | r¹ :—:— | d¹ :—:— |

| s :s.-.s | l.-.d¹ : s | :r¹ | d¹.m.f : s.l.s | r¹ :d¹ ‖

10. Place crosses against the following pitch names to show the average compass of the voices of children from eight to ten years of age. Say whether your statements refer to boys or girls.

Trebles + + +
C, D, E, F, G, A, B, C D E F G A B C¹ D¹ E¹ F¹ G¹ A¹ B¹ C²
Altos + + +

(See Answer 10 above.)

11. If you were an adjudicator at a competition of school choirs, under what heads would you give marks?

(See Answer 11 above.)

12. State the meanings of the following terms:

(1) Forte. Loud.
(2) Presto. Very quick time.
(3) Dolce. Sweetly.
(4) M. 70. 70 beats per minute by the Metronome.

Male Candidates.

FIRST YEAR.

Algebra and Mensuration.

(*Three hours allowed for this paper.*)

Candidates are not permitted to answer more than NINE questions in Algebra and TWO questions in Mensuration.

The Solution must be given at such length as to be intelligible to the Examiner, otherwise the answer will be considered of no value.

Algebra.

1. Prove that the difference of the cubes of any two quantities divided by the difference of their squares = sum of the two quantities + their product divided by their sum.

Point out the difference between the algebraical *proof* of this proposition and the arithmetical *illustration* afforded by the substitution of numbers (*e.g.*, 7, 8), for the two quantities.

Algebraical proof—

Let a and b represent the two quantities,

Then, $\frac{a^3 - b^3}{a^2 - b^2}$

$= \frac{(a-b)(a^2 + ab + b^2)}{(a-b)(a+b)}$

$= \frac{a^2 + ab + b^2}{a+b}$

$= \frac{a^2 + 2ab + b^2 - ab}{a+b}$

$= \frac{(a+b)^2 - ab}{a+b}$

$= (a+b) - \frac{ab}{a+b}$.

Arithmetical illustration—

$\frac{8^3 - 7^3}{8^2 - 7^2} = \frac{512 - 343}{64 - 49} = \frac{169}{15} = 11 + \frac{4}{15}$

$= 11 + 4 - 4 + \frac{4}{15}$

$= 15 - \frac{60 - 4}{15}$

$= 15 - \frac{56}{15}$

$= (8 + 7) - \frac{8 \times 7}{15}$.

In the Algebraical proof we divide by the difference of the two quantities, and afterwards add and subtract the product of the two quantities divided by their sum to obtain the required result.

In the Arithmetical illustration we add and subtract a number that will make the first quantity equal to the sum of the given numbers to obtain the required result.

2. Resolve into elementary factors—

(1.) $x^2 - 14x - 51$. (2.) $x^3 - 729$.

(3.) $(x + a)^4 - (x - a)^4$.

and prove that

$a^3(b - c) + b^3(c - a) + c^3(a - b)$
$= (a + b + c)[a^2(b - c) + b^2(c - a) + c^2(a - b)]$.

(1.) $x^2 - 14x - 51 = (x - 17)(x + 3)$,
since $-17 + 3 = -14$,
and $-17 \times 3 = -51$.

(2.) $x^3 - 729$
$= (x^3 - 9^3)$
$= (x - 9)(x^2 + 9x + 81)$.

(3.) $(x+a)^4-(x-a)^4$
$=[(x+a)^2+(x-a)^2][(x+a)^2-(x-a)^2]$
$=(x^2+2ax+a^2+x^2-2ax+a^2)$
$(x^2+2ax+a^2-x^2+2ax-a^2)$
$=(2x^2+2a^2)\times 4ax$
$=8ax(a^2+x^2)$.

$(a+b+c)[a^2(b-c)+b^2(c-a)+c^2(a-b)]$
$=a^3(b-c)+a^2(b+c)(b-c)+b^3(c-a)$
$+b^2(c+a)(c-a)+c^3(a-b)$
$+c^2(a+b)(a-b)$
$=a^3(b-c)+a^2(b^2-c^2)+b^3(c-a)$
$+b^2(c^2-a^2)+c^3(a-b)+c^2(a^2-b^2)$
$=a^3(b-c)+a^2b^2-a^2c^2+b^3(c-a)$
$+b^2c^2-a^2b^2+c^3(a-b)+a^2c^2-b^2c^2$
$=a^3(b-c)+b^3(c-a)+c^3(a-b)$.

3. If a quantity is a factor of a and b, it is also a factor of $ma+nb$.

Find the G. C. M. of $4x^3-27x^2+58x-39$ and $x^3-8x^2+19x-12$.

Let f be a factor of a and b,

And suppose $a=fx$, $b=fy$

Then, $ma=mfx$, $nb=nfy$

$\therefore ma+nb=mfx+nfy$
$=f(mx+ny)$;

$\therefore$ f is a factor of $ma+nb$.

$x^3-8x^2+19x-12)\,4x^3-27x^2+58x-39\,(4$
$4x^3-32x^2+76x-48$
$5x^2-18x+9$

$x^3-8x^2+19x-12$
5
$5x^2-18x+9)\,5x^3-40x^2+95x-60\,(x$
$5x^3-18x^2+9x$
$-2\,|\,-22x^2+86x-60$
$11x^2-43x+30$
5
$55x^2-215x+150\,(11$
$55x^2-198x+99$
$-17\,|\,-17x+51$
$x-3$

$x-3)\,5x^2-18x+9\,(5x-3$
$5x^2-15x$
$-3x+9$
$-3x+9$

$\therefore$ G. C. M. $=x-3$.

4. Simplify—

$$\frac{a}{b}-\frac{a^2-b^2}{b^2}x+\frac{a(a^2-b^2)x^2}{b^2(b+ax)}$$

and find the value of

$$\left(\frac{x}{x-1}\right)^2+\left(\frac{x}{x+1}\right)^2 \text{ when } x=\sqrt{\frac{a-b}{a+b}}$$

$$\frac{a}{b}-\frac{a^2-b^2}{b^2}x+\frac{a(a^2-b^2)x^2}{b^2(b+ax)}$$
$$=\frac{ab(b+ax)-(a^2-b^2)(b+ax)x+a(a^2-b^2)x^2}{b^2(b+ax)}$$
$$=\frac{ab^2+a^2bx-(a^2b+a^3x-b^3-ab^2x)x+a^3x^2-ab^2x^2}{b^2(b+ax)}$$
$$=\frac{ab^2+a^2bx-a^2bx-a^3x^2+b^2x+ab^2x^2+a^3x^2-ab^2x^2}{b^2(b+ax)}$$
$$=\frac{ab^2+b^3x}{b^2(b+ax)}$$
$$=\frac{b^2(a+bx)}{b^2(b+ax)}$$
$$=\frac{a+bx}{b+ax}.$$ Ans.

$$\left(\frac{x}{x-1}\right)^2+\left(\frac{x}{x+1}\right)^2$$
$$=\frac{x^2(x+1)^2+x^2(x-1)^2}{(x^2-1)^2}$$
$$=\frac{x^4+2x^3+x^2+x^4-2x^3+x^2}{(x^2-1)^2}$$
$$=\frac{2x^4+2x^2}{(x^2-1)^2}$$
$$=\frac{2x^2(x^2+1)}{(x^2-1)^2}$$
$$=\frac{2\times\frac{a-b}{a+b}\left(\frac{a-b}{a+b}+1\right)}{\left(\frac{a-b}{a+b}-1\right)^2}$$
$$=\frac{\frac{2(a-b)}{a+b}\times\frac{a-b+a+b}{a+b}}{\left(\frac{a-b-a-b}{a+b}\right)^2}$$
$$=\frac{\frac{4a(a-b)}{(a+b)^2}}{\left(-\frac{2b}{a+b}\right)^2}$$
$$=\frac{4a(a-b)}{4b^2}$$
$$=\frac{a(a-b)}{b^2}$$ Ans.

5. Find the square root of

$$16x^6-24x^5+33x^4-50x^3+33x^2-24x+16,$$

and prove that

$$\left(\frac{2a}{a-b}-1\right)^2+(1-b^2)\left[\left(\frac{2}{a-b}\right)^2-1\right]$$

is a square.

$4x^3-3x^2+3x-4\,|$

$16x^6-24x^5+33x^4-50x^3+33x^2-24x+16$
$16x^6$
$8x^3-3x^2\,|\,-24x^5+33x^4$
$-24x^5+9x^4$
$8x^3-6x^2+3x\,|\,24x^4-50x^3+33x^2$
$24x^4-18x^3+9x^2$
$8x^3-6x^2+6x-4\,|\,-32x^3+24x^2-24x+16$
$-32x^3+24x^2-24x+16$

$\therefore$ Square root $=4x^3-3x^2+3x-4$
$=4(x^3-1)-3x(x-1)$
$=(x-1)[4(x^2+x+1)-3x]$
$=(x-1)(4x^2+4x+4-3x)$
$=(x-1)(4x^2+x+4)$.

$$\left(\frac{2a}{a-b}-1\right)^2+(1-b^2)\left[\left(\frac{2}{a-b}\right)^2-1\right]$$
$$=\frac{4a^2}{(a-b)^2}-\frac{4a}{a-b}+1+\frac{4}{(a-b)^2}-1$$
$$-\frac{4b^2}{(a-b)^2}+b^2$$
$$=\frac{4a^2-4b^2+4}{(a-b)^2}-\frac{4a}{a-b}+b^2$$
$$=\frac{4a^2-4b^2+4-4a(a-b)}{(a-b)^2}+b^2$$
$$=\frac{4a^2-4b^2+4-4a^2+4ab}{(a-b)^2}+b^2$$
$$=\frac{4+4b(a-b)}{(a-b)^2}+b^2$$
$$=\frac{4}{(a-b)^2}+\frac{4b}{a-b}+b^2$$
$$=\left(\frac{2}{a-b}+b\right)^2.$$

6. Solve the equations—

$$(1.)\ \frac{a}{x-a}+\frac{b}{x-b}=\frac{a+b}{x-a-b}.$$

$$(2.)\ \frac{1}{x^2-1}-\frac{1}{1-x}=\frac{7}{8}-\frac{1}{x+1}.$$

$$(1.)\ \frac{a}{x-a}+\frac{b}{x-b}=\frac{a+b}{x-a-b}$$

$$\frac{a}{x-a}=\frac{a+b}{x-a-b}-\frac{b}{x-b}$$

$$=\frac{ax+bx-ab-b^2-bx+ab+b^2}{(x-b)(x-a-b)}$$

$$=\frac{ax}{(x-b)(x-a-b)}$$

$$\frac{1}{x-a}=\frac{x}{(x-b)(x-a-b)}$$

$$(x-b)(x-a-b)=x(x-a)$$

$$x^2-ax-2bx+ab+b^2=x^2-ax$$

$$-2bx=-ab-b^2$$

$$2x=a+b$$

$$\therefore x=\tfrac{1}{2}(a+b).$$

$$\frac{1}{x^2-1}-\frac{1}{1-x}=\frac{7}{8}-\frac{1}{x+1}$$

$$\frac{1}{x^2-1}+\frac{1}{x-1}+\frac{1}{x+1}=\frac{7}{8}$$

$$\frac{1+x+1+x-1}{x^2-1}=\frac{7}{8}$$

$$\frac{2x+1}{x^2-1}=\frac{7}{8}$$

$$16x+8=7x^2-7$$

$$7x^2-16x=15$$

$$x^2-\frac{16x}{7}=\tfrac{15}{7}$$

$$x^2-\frac{16x}{7}+(\tfrac{8}{7})^2=\tfrac{15}{7}+\tfrac{64}{49}$$

$$=\frac{64+105}{49}$$

$$=\tfrac{169}{49}$$

$$x-\tfrac{8}{7}=\pm\tfrac{13}{7}$$

$$x=\pm\tfrac{13}{7}+\tfrac{8}{7}$$

$$\therefore x=3,\text{ or }-\tfrac{5}{7}.$$

7. A number (n) is divided into three parts such that one-third of the number exceeds the first part as much as the second part exceeds one-fourth of the number. Find the third part.

Let x = First part of the number,
and y = Second " " " ,
then, $n-(x+y)$ = Third " " " ;

$$\therefore \frac{n}{3}-x=y-\frac{n}{4}$$

$$\frac{n}{3}+\frac{n}{4}=x+y$$

$$\frac{7n}{12}=x+y$$

$$\therefore \text{Third part}=n-\frac{7n}{12}$$

$$=\frac{5n}{12}.\ \text{Ans.}$$

8. Find the sum of n terms of an A. P. of which a is the first term and b the common difference.

Two clerks are engaged at the same time. A chooses a salary of £100 a year, increasing £20 annually. B chooses a salary of £50 per half year, increasing £5 every half year. Which makes the better bargain, and how much more than the other has he received at the end of 20 years?

Let s denote the sum of the terms and l the last term.

Then, $s=a+(a+b)+(a+2b)+\ldots+l$

Writing the series in the reverse order,

$$s=l+(l-b)+(l-2b)+\ldots+a,$$

By addition,

$$2s=(a+l)+(a+l)+(a+l)+\ldots \text{ to } n \text{ terms}$$
$$=n(a+l),$$

$$\therefore s=\frac{n}{2}(a+l);$$

But $l=a+(n-1)b$,

$$\therefore s=\frac{n}{2}[2a+(n-1)b].$$

A	B
a = £100	a = £50
b = £20	b = £5
n = 20	n = 40

$\therefore s=$ £$[200+(19\times 20)]\times\frac{20}{2}$ for A,
And $s=$ £$[100+(39\times 5)]\times\frac{40}{2}$ for B,
$\therefore$ Amount for A = £580 × 10
= £5,800;
" " B = £295 × 20
= £5,900;

$\therefore$ B makes the better bargain, and difference = £100 in 20 years.

9. Investigate a test to determine if three quantities, a, b, c, are in G. P.

Apply the test to (1.) $3\frac{1}{2}$, $2\frac{1}{4}$, $1\frac{2}{8}$.
(2.) 4·5, ·75, ·125.

A G. P. is such that the nth term = sum of the succeeding terms ad inf. Find the common ratio.

If a, b, c, be in G. P.,
Then $b=ar$ (where r is common ratio)

$$c=br;$$

$$\therefore \frac{b}{c}=\frac{ar}{br}=\frac{a}{b}$$

Wherefore $b^2=ac$.

(1.) $(2\frac{1}{4})^2=(\frac{9}{4})^2=\frac{81}{16}$;
$(3\frac{1}{2}\times 1\frac{1}{8})=\frac{7}{2}\times\frac{9}{8}=\frac{63}{16}$;
$\therefore$ This series is not in G. P.

(2.) $\cdot 75^2=\cdot 5625$;
$4\cdot 5\times\cdot 125=\frac{1}{8}$ of $4\cdot 5=\cdot 5625$;
$\therefore$ This series is in G. P.

The sum of an infinite number of terms of a G. P. is $\frac{a}{1-r}$.

The nth term $=ar^{n-1}$,

The sum of the series ad infinitum commencing at the $(n+1)$th term $=\frac{ar^n}{1-r}$;

$$\therefore ar^{n-1}=\frac{ar^n}{1-r}$$

Dividing by ar^{n-1} } $1=\frac{r}{1-r}$

$$1-r=r$$

$$1=2r$$

$$\therefore r=\tfrac{1}{2}.$$

$\therefore$ Common ratio $=\frac{1}{2}$.

10. If $(a+b+c+d)(a-b-c+d)=(a-b+c-d)(a+b-c-d)$,
then $a:b::c:d$,

and $\frac{1}{ma}+\frac{1}{nb}+\frac{1}{pc}+\frac{1}{qd}=\frac{1}{bc}\left[\frac{a}{q}+\frac{b}{p}+\frac{c}{n}+\frac{d}{m}\right]$.

If $(a+b+c+d)(a-b-c+d)=(a-b+c-d)(a+b-c-d)$,
$[(a+d)+(b+c)][(a+d)-(b+c)]=[(a-d)-(b-c)][(a-d)+(b-c)]$,
$(a+d)^2-(b+c)^2=(a-d)^2-(b-c)^2$,
$(a+d)^2-(a-d)^2=(b+c)^2-(b-c)^2$,
$4ad=4bc$,
$ad=bc$,
$\frac{a}{b}=\frac{c}{d}$

$\therefore a:b::c:d.$

If $\frac{1}{ma} + \frac{1}{nb} + \frac{1}{pc} + \frac{1}{qd}$

$$= \frac{1}{bc}\left[\frac{a}{q} + \frac{b}{p} + \frac{c}{n} + \frac{d}{m}\right],$$

$$\frac{npqbcd + mpqacd + mnqabd + mnpabc}{mnpqabcd}$$

$$= \frac{1}{bc}\left[\frac{mnpa + mnqb + mpqc + npqd}{mnpq}\right],$$

$$npqbcd + mpqacd + mnqabd + mnpabc$$
$$= ad\,(mnpa + mnqb + mpqc + npqd)$$
$$= mnpa^2d + mnqabd + mpqacd + npqad^2,$$

$$npqbcd + mnpabc = mnpa^2d + npqad^2,$$

$$bc\,(mnpa + npqd) = ad\,(mnpa + npqd),$$

$$bc = ad,$$

$\therefore\ a : b :: c : d.$

Mensuration.

$\pi = \frac{22}{7}$.

1. To cover the floor of a room half as long again as it is wide with carpet $\frac{3}{4}$ yard wide priced 4s. 6d. per yard costs £11 5s. To paint $\frac{3}{5}$ths of the surface of the walls at 2d. per square foot costs half that sum. Find the dimensions of the room.

Area of walls = ($\frac{1}{2}$ of £11 5s. ÷ 2d.) sq. ft. × $\frac{4}{3}$

$$= \left(\frac{1}{2} \times \frac{\overset{25}{225}}{1} \times \frac{3}{9} \times \frac{4}{3} \times \frac{1}{9}\right) \text{sq. yds.}$$

= 100 sq. yds.;

Quantity of carpet required = (£11 5s. + 4s. 6d.) yds.

$$= \left(\frac{\overset{25}{225}}{1} \times \frac{2}{9}\right) \text{yds.}$$

= 50 yds.;

Area of floor = 50 yds. × $\frac{3}{4}$ yd.

= $\frac{75}{2}$ sq. yds.;

Length × Breadth = Area,

$\frac{3}{8}$ Breadth × Breadth = $\frac{75}{2}$ sq. yds.,

$$\text{Breadth}^2 = \left(\frac{\overset{25}{75}}{2} \times \frac{8}{3}\right) \text{sq. yds.}$$

= 25 sq. yds.,

$\therefore$ Breadth = 5 yds.;

Length = $\frac{8}{3}$ Breadth = 7$\frac{1}{3}$ yds.;

Perimeter of room × Height = Area of walls,

2 (5 + 7$\frac{1}{3}$) yds. × Height = 100 sq. yds.,

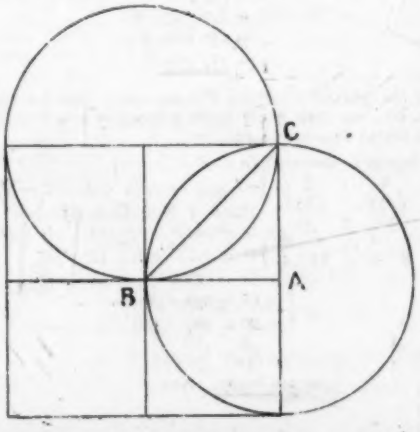
25 yds. × Height = 100 sq. yds.,

$\therefore$ Height = 100 sq. yds. ÷ 25 yds.

= 4 yds.;

Length of room = 7$\frac{1}{3}$ yards
Breadth ,, = 5 ,,
Height ,, = 4 ,,
} Ans.

2. On two adjacent sides of a square as diameters, circles are described. Find the area common to both circles, the side of the square being given.



Let a represent the side of the square;

Area of sector ABC = $\frac{1}{4}$ area of circle

$$= \frac{1}{4} \text{ of } \left(\frac{a}{2}\right)^2 \times \frac{\overset{11}{22}}{7}$$

$$= \frac{11a^2}{56};$$

,, triangle ABC = $\frac{1}{2}$ AB^2

$$= \frac{1}{2} \text{ of } \left(\frac{a}{2}\right)^2$$

$$= \frac{a^2}{8};$$

$\therefore$ Area common to both circles $= \left(\frac{11a^2}{56} - \frac{a^2}{8}\right) \times 2$

$$= \frac{11a^2 - 7a^2}{56} \times 2$$

$$= \frac{4a^2}{28}$$

$$= \frac{a^2}{7}$$

= $\frac{1}{7}$ Area of square. Ans.

3. A square garden contains 4 equal circular flower beds, and the whole length of the borders of the beds = length of the garden wall; what fraction of the area of the garden is occupied by the flower beds?

Let a represent the side of the garden,

Then a represents also the circumference of each flower bed;

Diameter of each flower bed = $\frac{7}{22}a$,

Radius ,, ,, ,, = $\frac{7}{44}a$,

Area ,, ,, ,, $= \frac{a}{2} \times \frac{7a}{44}$

$$= \frac{7a^2}{88},$$

$\therefore$ Area of the flower beds $= \frac{7a^2}{88} \times 4$

$$= \frac{7}{22}a^2$$

= $\frac{7}{22}$ of area of garden. Ans.

Male Candidates.

FIRST YEAR.

Arithmetic.

(*Two hours and a half allowed for this Paper.*)

Candidates are not permitted to answer more than TEN questions, and are advised to answer the first.

The *solution* must be given at such length as to be intelligible to the Examiner, otherwise the answer will be considered of no value.

1. (*a*)—State and prove the rule for bringing a mixed number into the form of an improper fraction. (*b*) How would you get over the difficulty of reducing yards to poles (long measure), in considering the point for the first time with a fourth standard? (*c*) Explain briefly why we cannot find the exact square root of ·625. (*d*) Define *least common multiple, circulating decimal, stock, brokerage, compound interest.*

(*a*) *Rule* to reduce a mixed number to an improper fraction:—Multiply the integer by the denominator of the fraction; add the numerator, and place the denominator under the sum.

Proof:—By multiplying the integer by the denominator we obtain the number of required parts in the whole number, and by adding the number of parts in the fraction we obtain the number of parts in the whole number and the fraction or in the mixed number.

(*b*) Take simple examples, as 11 and 22 ÷ 5$\frac{1}{2}$, and show that we can easily see that the first result will be 2, and the second 4; then show that these results could be obtained by reducing both to halves, and thus avoid the difficulty of dividing by 5$\frac{1}{2}$.

In questions we reduce the yards to half-yards and divide by 11 (the number of halves in 5$\frac{1}{2}$), and the quotient will be poles, but care must be taken with the remainder, as it will be in half-yards, and must be reduced to yards.

(*c*) Square of ·1 = ·01,
,, ·01 = ·0001,
,, ·001 = ·000001, &c.

We thus see that the number of decimals in the square is always twice the number of decimals in the root, and therefore is always an even number of places. Consequently we cannot find the exact square root of ·625, as the number of decimals is odd.

(*d*) The *Least Common Multiple* of two or more numbers is the least number which will contain each of the numbers an exact number of times.

A *Circulating Decimal* is an indeterminate decimal, and the same figures must come round again, or recur, or be repeated, since we always affix a cipher to the dividend, whenever any former remainder recurs, the quotient therefore will also recur.

Now when we divide by any number, the remainder must always be less than that number, and therefore some remainder must recur, before we have obtained a number of remainders equal to the number of units in the divisor.

Circulating decimals are also called Repeating or Recurring decimals.

Stock is the capital of trading companies, or money borrowed by governments or public bodies, at so much per cent., to defray the expenses of the nation or district.

Brokerage is the commission paid to the persons (called Brokers), who effect the necessary sales of stock, and whose business it is to transfer stock and shares from one name to another.

The commission is always $\frac{1}{4}$ per cent. or 2s. 6d. for every £100 stock in the funds, but is higher for other stock.

The *Interest* is *Compound* when the interest, as soon as it becomes due, is added to the principal and forms a new principal for the next year or period of time.

2. A number is divided by 210 in three steps, the factors being 5, 6, 7 in order; the remainders are 2, 3, 4. What would have been the remainders had the order 7, 6, 5 been taken?

Total remainder = (5 × 6 × 4) + (5 × 3) + 2
= 120 + 15 + 2
= 137;
First remainder in second case
= remainder of 137 ÷ 7
= 19 + 4 remainder,
Second remainder in second case
= remainder of 19 ÷ 6
= 3 + 1 remainder,
∴ Remainders = 4, 1, 3. Ans.

3. Calculate whether posting at a shilling per mile is less or more expensive than posting at 65 centimes per kilometre, the following being given:—

1 metre = 39·37 inches.
1 kilometre = 1,000 metres.
100 centimes = 1 franc.
25 francs = £1.

Cost per mile in second case = $\frac{13}{20}$ of £$\frac{1}{25}$ + $\frac{20}{25}$ of $\frac{6336}{3937}$s.
= $\left(\frac{13}{20} \times \frac{20}{25} \times \frac{6336}{3937}\right)$s.
= $\frac{82368}{98425}$ s.;
∴ First charge is more expensive. Ans.

4. Simplify $\frac{117}{154}$ of $2\frac{24}{65}$ + $\frac{132}{153}$ of $\frac{136}{165}$.

$$\frac{117}{9}\text{ of }\frac{2\frac{24}{65}}{8} + \frac{132}{153}\text{ of }\frac{136}{165}$$
$$= \frac{\overset{13}{117}}{154}\text{ of }\frac{\overset{22}{176}}{65} + \frac{\overset{12}{132}}{153}\text{ of }\frac{\overset{8}{136}}{165}$$
$$= \frac{11}{7} + \frac{8}{5}$$
$$= \frac{648 + 224}{315}$$
$$= \frac{872}{315}$$
$$= 2\tfrac{242}{315}.\text{ Ans.}$$

5. Find the value of 3·075 of a ton + ·142857 of a cwt. + $2\frac{1}{14}$ cwt., and reduce the result to the decimal of 9 tons 12 cwt. 3 qrs.

	tons.	cwt.	qrs.
3·075 tons = $3\frac{3}{40}$ tons =	3	1	2
·142857 cwt. = $\frac{1}{7}$ cwt. =			1
$2\frac{1}{14}$ cwt. =		2	2
	3	4	1

Fraction = $\frac{3 \text{ tons } 4 \text{ cwt. } 1 \text{ qr.}}{9 \text{ tons } 12 \text{ cwt. } 3 \text{ qrs.}}$
= $\frac{1}{3}$
∴ Decimal = ·3̇. Ans.

6. A man buys a farm of 120 acres for £3,225: he repairs the buildings and lets it at 28s. per acre, thereby getting a return of $3\frac{1}{3}$ per cent. on his money. How much did he spend on repairs?

Rent = 28s. × 120
= £(28 × 6)
= £168;
Total cost = £168 × $\frac{100}{3\frac{1}{3}}$
= £168 × $\frac{300}{10}$
= £24 × 200
= £4,800;
∴ Cost of repairs = £4,800 − £3,225
= £1,575. Ans.

7. A watch which is set correctly at noon indicates 10 minutes after 9 the same evening when the true time is 10. What is the true time when the watch indicates 11 on the same evening?

At 10 minutes after 9 by the watch the true time is 10 o'clock,
∴ Loss = 50 min.;

hrs.	min.		hrs.	min.	
9	10	:	11	:: 50	: Loss.

$\frac{60}{550}$
11
= 1 hour
∴ True time = 12 o'clock at night, or midnight. Ans.

8. The breadth of a rectangular field is $\frac{3}{7}$ of its length, and its area is 405,741 sq. yds. Find the sides.

Length × Breadth = Area;
Length × $\frac{3}{7}$ Length = 405,741 sq. yds.,
$\frac{3}{7}$ Length² = 405,741 sq. yds.,
Length² = 405,741 sq. yds. × $\frac{7}{3}$
= 135,247 sq. yds. × 7
= 946,729 sq. yds.
∴ Length = $\sqrt{946,729}$ sq. yds.

```
94'67'29(973
 81
187 | 1367
      1309
1943 | 5829
       5829
```

= 973 yds.
Breadth = $\frac{3}{7}$ of 973 yds.
= 139 yds. × 3
= 417 yds.

9. If the gas for 7 burners, 6 hours every day, for 19 days, cost 8s. 6d., for how many hours every day may 8 burners be lighted for 30 days for 11s. 4d.?

burners		burners	
8	:	7	hrs.
days		days	:: 6 : No. of hrs. per day.
30	:	19	
s. d.		s. d.	
8 6	:	11 4	

$$= \frac{7 \times 19 \times \overset{17}{136} \times 6}{8 \times 30 \times \underset{5}{102}}\text{ hrs.}$$
$$= \frac{323}{80}\text{ hrs.}$$
$$= 4\tfrac{3}{80}\text{ hours.}\quad\text{Ans.}$$

10. A sub-collector receives 10 per cent. of the collector's commission after 45 per cent. of it has been deducted for office expenses. The collector's commission is $1\frac{1}{2}$ per cent. on a rateable value of £33,000. What will the sub-collector receive?

Amount received by sub-collector

$= 10\%$ of 55% of $1\frac{1}{2}\%$ of £33,000

$= \frac{1}{10}$ of $\frac{11}{20}$ of $\frac{3}{2}$ of £330

$= £\frac{1089}{40}$

$= £27\ 4s.\ 6d.$ Ans.

11. In what time will £6,755 amount to £7,759 16s $1\frac{1}{2}$d. at $3\frac{1}{2}$ per cent. per annum simple interest?

£6755 × $3\frac{1}{2}$ = 20265. Interest for a year = £236 8s. 6d.

3377 10s.

£236·42 10s.

20

s. 8·50

12

d. 6·0

£	s.	d.		£	s.	d.	
				7759	16	$1\frac{1}{2}$	
£	s.	d.		6755			year
236	8	6	:	1004	16	$1\frac{1}{2}$	:: 1 : Time.

20 20

4728 20096

12 12

56742 241153

2 2

113484)482307(4

453936

28371

113484 = $\frac{1}{4}$

∴ Time = $4\frac{1}{4}$ years. Ans.

12. Find the exact difference between the compound interest on £500, reckoned half-yearly, at £1 19s. 3d. per cent. per half-year, and the interest on the same sum at 4 per cent. per annum at the end of 1 year.

Interest for first half-year = £1 19s. 3d. × 5

= £9 16s. 3d.;

£	£	s.	d.	£	s.	d.	
∴ 100	: 509	16	3	:: 1	19	3	: Interest for second half-year.
20	20			20			
2000	10196			39			
4	4			12			
8000	40785			471			
1600	8157						
	471						
	8157						
	57009						
	32628						

16,00 | 38419,47

12 | 2401 $\frac{847}{1600}$

2,0 | 20,0 $1\frac{847}{1600}$d.

£10 0s. $1\frac{847}{1600}$d.

£9 16s. 3d.

Interest in first case = £19 16s. $4\frac{847}{1600}$d.

Interest in second case = £20;

∴ Difference = £20 − £19 16s. $4\frac{847}{1600}$d.

= 3s. $7\frac{753}{1600}$d. Ans.

13. A man invests the present worth of £5,556 due $4\frac{1}{2}$ years hence at $3\frac{1}{3}$ per cent. per annum simple interest in 4 per cent. railway debentures at 125. What income does he obtain?

(Brokerage may be neglected.)

Interest on £100 = £$3\frac{1}{3} \times 4\frac{1}{2}$

= £$(\frac{10}{3} \times \frac{9}{2})$

= £$\frac{90}{6}$

= £$15\frac{3}{4}$;

£	£	£	
∴ $15\frac{3}{4}$	: 5556	:: 100	: Present Worth.

4 4

463)2222400(£4800

1852

3704

3704

£	£	£	
∴ 125	: 4800	:: 4	: Income.
5	192		
	4		
5	768		
	£153 12s.		

∴ Income = £153 12s. Ans.

Male Candidates.

FIRST YEAR.

Mental Arithmetic.

Twenty minutes allowed for this paper.

You are to enter your answer in the space (———) left for it after each question. Nothing is to be written on this paper except the particulars required in the Table and the answers (which must be written in ink only) to the questions. *No Erasures or Alterations are permitted.* They will be marked as errors.

1. $\frac{7}{13}$ of $\frac{52}{57}$ of 4s. 9d. to the decimal of £1 = ...(———).

$= \frac{7}{13} \times \frac{4}{\frac{52}{57}} \times \frac{57}{240} = \frac{7}{60} = .116.$

2. The distance between two wickets was marked out for 22 yards, but the yard measure was $\frac{7}{10}$ of an inch too short: the actual distance = ...(———).

= 22 yds. − ($\frac{7}{10}$ × 22) in. = 22 yds. − $15\frac{3}{5}$ in.

= 22 yds. − 1 ft. $3\frac{3}{5}$ in. = 21 yds. 1 ft. $8\frac{2}{5}$ in.

3. The fourth proportional to 119, 153, 154 = ...(———).

= 7 : 9 :: 154 : 4th term = 22 × 9 = 198.

4. A starts to ride at 6 miles an hour: in 20 minutes B follows him from the same starting point at 9 miles an hour: B will overtake A in the time = ...(———).

= ($\frac{1}{3}$ of 6 miles ÷ 3 miles) hr. = $\frac{2}{3}$ hr. = 40 min.

5. A carpet $\frac{3}{4}$ of a yard wide is required for a room 24 ft. by 27 ft. at 3s. per yard: its price = ...(———).

= 24 × 27 ÷ 9 = 72 × $\frac{3}{4}$ = (108 × 3)s.

= 324s. = £16 4s.

6. Interest on £9,289 8s. 4d. for 4 years at $2\frac{1}{2}$ per cent. per annum, simple interest = ...(———).

= $2\frac{1}{2}\%$ × 4 = 10% = $\frac{1}{10}$ of £9,289 8s. 4d.

= £928 18s. 10d.

7. 1 cwt. 3 qrs. 21 lbs. at 13s. 4d. per cwt. = ...(———).

= 2 cwt. − 7 lbs. = 2 cwt − $\frac{1}{16}$ cwt.

= 13s. 4d. × 2 − $\frac{1}{16}$ of 13s. 4d.

= £1 6s. 8d. − 10d. = £1 5s. 10d.

8. $87^2 - 47^2$ = ...(———).

$= (87 + 47)(87 - 47)$
$= 134 \times 40 = 5{,}360.$

9. 24 per cent. is gained by selling a horse for £46 10s.; cost price = ...(———).

$= \frac{100}{124}$ or $\frac{25}{31}$ of £46 10s.
$= £1\ 10s. \times 25 = £37\ 10s.$

10. Present worth of £465 12s. due 2½ years hence at 8 per cent. per annum simple interest = ...(———).

$= \frac{100}{100 + 2\frac{1}{2} \times 8}$ or $\frac{100}{120}$ or $\frac{5}{6}$ of £465 12s.
$= £465\ 12s. - \frac{1}{6}$ of £465 12s.
$= £465\ 12s. - £77\ 12s. = £388.$

11. A man gave £40 for 77 cwt., and sold them at £·63 per cwt.: his gain per cent = ...(———).

$= £\frac{7}{11} \times 77 = £49 - £40 = £9 \times \frac{100}{40}$
$= £9 \times \frac{5}{2} = 22\frac{1}{2}$ per cent.

12. $90 \times \frac{\cdot 068}{1\cdot 24}$ = ...(———).

$= 90 \times \frac{68}{1000} \times \frac{5}{\frac{124}{2}} = 5.$

13. 30 lbs. tea at 1s. 4d. per lb. are mixed with 16 lbs. at 2s. 6d. per lb.; the mixture is sold so as to gain 15 per cent.; selling price per lb. = ...(———)

$= 1s.\ 4d. \times 30 + 2s.\ 6d. \times 16 = 40s. + 40s.$
$= \frac{4}{80s.} \times \frac{\frac{23}{115}}{\frac{100}{5}} = 92s. \div 46 = 2s.$

14. If $[(17 + 22) \div 13] \times 19 + 20 - 29 = x$;
then $3x + 16 + 53 - 61$ = ...(———).
$= 39 \div 13 = 3 \times 19 = 57 + 20 - 29 = 57 - 9 = 48;$
$= 3 \times 48 \div 16 = 9 + 53 - 61 = 9 - 8 = 1.$

ALTERNATIVE PAPER.

1. $90 \times \frac{\cdot 076}{1\cdot 38}$ = ...(———).

$= 90 \times \frac{76}{1000} \times \frac{5}{\frac{138}{2}} = 5.$

2. $97^2 - 57^2$ = ...(———).
$= (97 + 57)(97 - 57)$
$= 154 \times 40 = 6{,}160.$

3. If $[(19 + 36) \div 11] \times 18 + 22 - 24 = x$;
then $2x \div 11 + 54 - 62$ = ...(———).
$= 55 \div 11 = 5 \times 18 = 90 + 22 - 24$
$= 90 - 2 = 88;$
$= 2 \times 88 \div 11 = 16 + 54 - 62$
$= 16 - 8 = 8.$

4. Interest on £6,179 1s. 8d. for 1 year at 10 per cent. per annum = ...(———).

$= 10\% = \frac{1}{10}$ of £6,179 1s. 8d.
$= £617\ 18s.\ 2d.$

5. 16 per cent. is lost by selling a horse for £31 10s.; cost price = ...(———).

$= \frac{100}{100 - 16}$ or $\frac{100}{84}$ or $\frac{25}{21}$ of £31 10s.
$= £1\ 10s. \times 25 = £37\ 10s.$

6. Mean proportional to 252 and 847 = ...(———).

$= \sqrt{252 \times 847} = \sqrt{36 \times 7 \times 7 \times 121}$
$= 6 \times 7 \times 11 = 462.$

7. Present worth of £410 8s. due 5 years hence at 4 per cent. per annum simple interest = ...(———).

$= \frac{100}{100 + 4 \times 5}$ or $\frac{100}{120}$ or $\frac{5}{6}$ of £410 8s.
$= £410\ 8s. - \frac{1}{6}$ of £410 8s.
$= £410\ 8s. - £68\ 8s. = £342.$

8. $\frac{4}{11}$ of $\frac{33}{68}$ of 4s. 3d. reduced to the decimal of £1 = ...(———).

$= \frac{4}{11} \times \frac{\frac{3}{33}}{\frac{68}{17}} \times \frac{\frac{3}{51}}{\frac{240}{80}} = \frac{3}{8} = \cdot 0375.$

9. 2 cwt. 2 qrs. 21 lbs. at 6s. 8d. per cwt. = ...(———).
$= 2$ cwt. $2\frac{3}{4}$ qrs. $= 2\frac{1}{16}$ cwt.
$= 6s.\ 8d. \times 2 + \frac{1}{16}$ of 6s. 8d.
$= 13s.\ 4d. + 5d. \times 11.$
$= 13s.\ 4d. + 4s.\ 7d. = 17s.\ 11d.$

10. A man gave £30 for 44 cwt. and sold them at £·72 per cwt.: his gain per cent. = ...(———).

$= £\frac{18}{11} \times 44 = £32 - £30 = £2 \times \frac{100}{30}$
$= £2 \times \frac{10}{3} = 6\frac{2}{3}$ per cent.

11. The distance between 2 wickets was marked out for 22 yards, but the yard measure was $\frac{1}{8}$ of an inch too short: the actual distance = ...(———).

$= 22$ yds. $- (\frac{1}{8} \times 22)$ in. $= 22$ yds. $- 13\frac{3}{4}$ in.
$= 22$ yds. $- 1$ ft. $1\frac{3}{4}$ in. $= 21$ yds. 1 ft. $10\frac{1}{4}$ in.

12. A starts to walk at 3 miles an hour: half an hour afterwards B follows him from the same starting point at 3½ miles per hour: B will overtake A in the time = ...(———).

$= (\frac{1}{2}$ of 3 miles $\div \frac{1}{2}$ mile) hrs. $= 3$ hours.

13. A carpet ¾ yard wide is required for a room 24 ft. by 18 ft. at 6s. per yard: its price = ...(———).

$= 24 \times 18 \div 9 = 48 \times \frac{4}{3} = (64 \times 6)$s.
$= 384$s. $= £19\ 4s.$

14. 24 lbs. tea at 1s. 8d. per lb. are mixed with 32 lbs. at 1s. 3d. per lb.: the mixture is sold so as to gain 40 per cent.: selling price per lb. = ...(———).

$= 1s.\ 8d. \times 24 + 1s.\ 3d. \times 32 = 40s. + 40s.$
$= \frac{4}{80s.} \times \frac{\frac{28}{140}}{\frac{100}{5}} = 112s. \div 56 = 2s.$

Political Economy.

1. What is the subject-matter of the Science of Political Economy? Show, by means of examples, how Economic Laws differ in character from Statutory Laws.

The subject-matter of Political Economy is Wealth. Political Economy enquires what Wealth is, how we can most easily increase it, and how we can most profitably consume it; how rent and wages arise; the benefits, mechanism, and policy of the exchange of wealth, and the general principles of taxation. The word 'law' is used in Economy in the same sense that it is used in Science generally. It merely states the coincidence between two sets of circumstances, one of which is called 'the cause,' and the other 'the effect.' The law is no more than the affirmation that certain results will be produced whenever certain causes operate. As an instance, we may take the Law of Diminishing Return, which tells us that, after a certain amount of capital has been expended upon a piece of land, additional equal increments of capital are followed by diminishing increments of produce. The laws of supply and demand admit of a simpler statement. A rise of price tends to produce a greater supply and a less demand; a fall in price tends to produce

a less supply and a greater demand. These are examples of scientific laws; they are simply general truths. Statutory laws, or Acts of Parliament, are mostly orders or prohibitions issued for the guidance or protection of the people generally, and for the most part enforced by penalties. They are, more or less, rules of conduct, imposed by the authority of the State. As examples, we may instance the factory laws, the laws relating to sanitary matters, the laws in relation to vaccination and compulsory attendance at school.

2. State and briefly explain the conditions on which the efficiency of human labour depends.

Human labour becomes more efficient in proportion as the expenditure of a definite amount of it is followed by a larger increase of wealth. Jevons says that in order to get as much wealth as we can with a reasonable amount of labour, we ought to labour (i.) At the best time; (ii.) At the best place; (iii.) In the best manner. We should do things when they can be done most easily, as making hay while the sun shines. We should work at the right place; iron should be smelted near a coal supply. For the world to grow rich easily, each nation should busy itself with what it can do best. And then every labourer should work to the greatest advantage. He cannot do this if he works alone. There must thus be a combination of labour, and this combination may be either simple, each man doing the same kind of work as his neighbour, but yet securing by their united efforts what they could never accomplish as individuals; or it may be complex, where different persons are occupied with different pursuits, but all aiming at one result. This separation of employments not only makes it possible to do what could never be done in any other way, such as printing a copy of the *Graphic*, for example, but it brings with it many collateral advantages. Workmen who are employed in one trade thereby acquire an enormous increase in dexterity, and save a considerable amount of time which would otherwise be spent in passing from one kind of work to another. Further, this subdivision of work into separate branches makes it possible for a man to pursue that calling for which he has special fitness, and in which he takes special delight. Society enjoys the benefit of superior skill at a moderate cost, it being obviously best for the whole community that each man should devote himself to what he can do best. The efficiency of labour is also promoted by inventions and the capital involved in adopting them, by the increased energy of the labourers, as well as by their increased skill and knowledge. Labourers should be properly fed, clothed, and housed. They should be well instructed. They should be temperate and well conducted. Their intelligence has a very direct bearing upon the quality and quantity of their work. Nor should their honesty and trustworthiness be overlooked, as not uncommonly a large proportion of the more intelligent and highly paid artisans are employed, not in producing useful commodities, but in seeing that the rest of the labourers do not neglect their duty.

3. Define capital, and explain the difference between fixed and circulating capital. In which, if either, class would you place a tricycle—(*a*) when in the maker's workshop; (*b*) when used by a tradesman delivering his goods; (*c*) when used for recreation?

Capital is that part of wealth which is destined to be employed reproductively. It affords shelter and protection to the labourer while doing his work; it supplies him with tools and materials, and thus enables him to wait for the reward of the enterprise he is engaged in. Without capital no important work would ever have been completed. Economists have to divide capital into two kinds—fixed and circulating. Adam Smith called that circulating which passes from hand to hand. Ricardo, however, altered the meaning of the term, and applied it to that which is soon destroyed, while fixed capital lasts long. The distinction is therefore one of longer or shorter duration, and is one of degree not of kind. Many things like food and raw materials can only be used once, others, like clothes and some of the instruments of labour, will last months, others again, like ships, railways, factories, and bridges last many years. It is not always easy to decide whether capital should be called fixed or circulating. It is like deciding whether a man is rich or poor; whether a day is hot or cold. A tricycle while in the maker's shop is capital, because we may fairly assume that he intends to exchange it for money which will be used in future production of wealth. It is also capital in a moderately fixed form. We may therefore say it is fixed capital. When used by a tradesman in delivering his goods it is really a tool employed for giving commodities an additional utility, that of being where they are wanted, and it is therefore capital. It is still fixed capital—capital which performs its functions many times before it is destroyed. When a tricycle is used for recreation it ceases to be capital at all; it is wealth used unproductively, like cricket balls and skates. It is not implied that wealth may not be very wisely and properly devoted to recreation and amusement; only when so used it does not result in an increase of useful commodities.

4. What are the advantages and disadvantages of such a localisation of industry as we see for example in the woollen trade in the West Riding of York, and in the hardware trade of Birmingham and its locality?

Such a localisation of industry tends to promote the education of skill and taste, and the general diffusion of technical knowledge among the workers. Living together, the artisans educate each other. The special aptitudes necessary in their handicrafts are learned while the children are young. The rival establishments stimulate each other. Any new invention is speedily adopted and often improved upon. Further, men clever in the special trades have not far to go for work, they are sure of employment. Men can find masters and masters can find men. The whole industry so localised admits of greater sub-division. Each department can be specially organised and developed. Very large factories become possible and great economies thus effected in buying and selling and in the employment of machinery. All these advantages cannot be had without some drawbacks. It is doubtful whether the concentration of a man's whole mind upon a single operation tends to improve his mind as a whole. He is often remarkably helpless when thrown into different circumstances. He would rarely succeed as a colonist. Again, where industry is thus localised serious disturbance may arise either from without or from within. A failure of the raw material, such as occurred in the cotton famine, plunges a whole county into misery; a strike, when unwisely decided upon and determinately carried out, may cause a very widespread distress. Where there is only one industry in a locality any serious disturbance in it affects the whole population in the district.

5. Give an account of the wages-fund theory. What arguments have been used against it?

What may be called the wages-fund of a country, says J. S. Mill, is made up of that part of the circulating capital of the country which is expended in the direct purchase of labour, together with all other funds that are paid in exchange of labour. The general rate of wages cannot rise but by an increase in the aggregate funds employed in hiring labourers, or in a diminution of the competitors for hire. This apparently means no more than that the quotient can only be increased by making the dividend greater or the divisor less. Mill, no doubt, meant more than this.

Wages are said to depend upon the relation of population and capital. But it is only a part of capital that is paid to the labourers in the shape of wages—that which is called the remuneratory part. The other and much the greater part, which is stored up in buildings and plant, does not affect the labourers' wages at all. The wage fund theory leads men to think that their wages are paid out of a predetermined sum, which is wholly independent of them or their work: that to get more of it, that sum must be increased or their number must be reduced. But surely their own efficiency counts for something, indeed for much, of the determination of the amount of their reward. Nor does it follow that an increase of the remuneratory capital of a country would necessarily, and at once, benefit the labourers. While it remained capital it would not raise their wages, though it might increase their stock of tools.

6. Explain and illustrate the economical terms Cost of Production, Effective Demand, Normal Value, Market Value. What causes the market value to undergo rapid changes, even while its normal value is constant?

The cost of production of a thing has been defined as the sum of the efforts and abstinences required for producing it. We find it convenient to express these in terms of money. We may then say that the cost of production is the sum of the prices which a person would pay for the efforts and sacrifices required for producing it, if he purchased them at their market prices. This is how a workman estimates what he can make an article for. Effective demand is the demand of those who are not merely desirous to possess some particular commodity, but who have also the requisite

means to purchase it. If a man wants to sell his house, his decision to take a definite sum is only influenced by the offers of those who have the money to purchase. Normal value is the expense of production. If shoes of a certain size and pattern can be made for 10s. a pair in Leicester, then 10s. is their normal value there. The market value is that which the commodity has in an actual exchange in a given market. The normal price of shoes may be 10s., but the market price on a certain day may be 8s. or 12s.

A change of fashion often causes an article to sell for less than its cost price. A sharp demand for a novelty may enable a seller to gain a large profit. Often the market price is the sport of large speculators. There has been a notorious illustration quite recently in the case of copper, the price of which has doubled during the last three months. A temporary failure in supply, or a great increase in the demand, results in wide market fluctuations in price. But these fluctuations are never permanent. The market price always tends to approximate to the normal price. Producers would not continue to make articles at a loss, and if the price admitted of very great profits production would receive such a stimulus as would soon largely increase the supply and thereby reduce the price.

7. How is the value of a commodity determined which is produced as incidental to some other important commodity, *e.g.*, molasses in the production of sugar, straw in the production of wheat?

In this case, as Mill points out, the cost of production does not determine the prices of the separate articles, but the price of the sum of them. It decides the joint value of the sugar and the molasses, the wheat and the straw, the gas and the coke, and other bye products, but not each of them separately. The actual market prices will be ruled by supply and demand, and in this way. Suppose the sugar is offered at a certain price and finds ready sale; and that the molasses is not all sold at the price at which it is offered. The price of the molasses will be lowered so as to dispose of it all, and the price of the sugar will be raised so as to make the sum of the prices equal to the total expense of production. This will be the normal price of the sum of them, and about this the market price may fluctuate. Occasionally a bye product may have zero value, may even have a negative value. Any scientific discovery which then turns such useless material to profitable account often brings about a rapid change in the price of the other joint product.

8. Explain why wages differ (*a*) between workmen in different occupations; (*b*) between workmen in the same occupation in different districts. Which of these differences tends to diminish, and why?

Adam Smith, in a well-known passage, gives five reasons why the wages in some occupations should be higher or lower than in others. These are:—(1) The agreeableness or disagreeableness of the employments themselves, *e.g.*, a general and a butcher. (2) The easiness and cheapness, or the difficulty and expense of learning the occupation, *e.g.*, an architect and a postman. (3) The constancy or inconstancy of employment, *e.g.*, a policeman and a dock labourer. (4) The small or great trust which must be imposed in those who exercise the employments, *e.g.*, a bank manager and a painter. (5) The probability or improbability of success in employments, *e.g.*, only a few barristers succeed: few clergymen fail. These causes, no doubt, go a long way toward explaining the great discrepancy in wages in different occupations. It must be remembered that anything which affects the numbers of men able and willing to do a particular kind of work affects the wages of such men. But the difference of the wages of workmen in the same occupation in different districts is very marked indeed, though less so than formerly. This difference is sure to diminish. As the labourers become more intelligent they will become more self-reliant, and will move from place to place so as to secure the highest reward for their services. Formerly there were many real obstacles to their moving from place to place over and above their natural disinclination to do so.

9. What is meant by the appreciation and the depreciation of gold? State the reasons for the conclusion that gold has undergone a considerable appreciation in the last ten years.

By the appreciation of gold is meant an increase in its general purchasing power. By depreciation of gold is meant a decrease in its general purchasing power. Since price is value expressed in terms of gold, gold cannot be said to have a price in the sense that other commodities have. But it has exchange value, and if we find that an ounce of gold will purchase more, not of any one commodity, but more of a very great number of commodities, we are led to conclude that the change is to be sought, not in those articles themselves, but in gold. It is exceedingly unlikely that a great number of articles would all be affected at the same time and in the same manner. A very much simpler hypothesis will explain all the facts—a rise in the value of gold. Owing to the gold discoveries in Australia, Professor Jevons concluded that the value of gold depreciated some 15 per cent. between 1848 and 1870, by comparing the prices of many hundreds of articles. The same kind of investigation shows that since 1876 gold has appreciated by something like 10 per cent. The full benefit of this, however, has by no means been felt by the poorer classes in large towns, except in the case of a few articles.

10. What conclusion as to the state of British trade can be drawn from the following passage? 'The value of our imports last month showed a decrease of 6 per cent. upon the total of a year ago. Exports, on the other hand, show an increase of nearly 5 per cent.'

We can conclude that we have supplied more foreign customers than in the previous year to the extent of 5 per cent. This will have given employment to a few more workmen, or will shortly do so, in replacing stocks. The value of the imports is 6 per cent. less. Nothing is said about the quantity of them. It is probably quite as large as before, and as we look upon the imports as the payment for our exports, though they are really very much more than that, we have, in all probability, been well rewarded for the goods sent abroad. Really very little can be concluded from the data given. If the imports had been much more than in the former year, it would not have proved that British trade was in a bad state. Other nations are so greatly indebted to us in many ways that our imports ought to exceed our exports very considerably. We cannot be sure how much of the repayment for these loans and services was represented in the returns for September, and no conclusion can therefore be drawn as to the profitableness of British trade as a whole.

11. State carefully the various functions of money, and the qualities a commodity must possess to fit it to serve as money. Define a pound sterling.

Money consists of something which all people in a country are willing to take in exchange. All economists are agreed that money has two important functions—a measure of value and a medium of exchange. Jevons adds two others, a store of value and a standard of value. (1) We express the value of everything in terms of money, for the sake of easy comparison. (2) As a medium of exchange, money saves us from the necessity of barter, which, while apparently simple, is beset with great practical difficulties.

(3) In the time of Elizabeth silver was the measure of value, and gold was the medium of exchange for large sums; precious stones were used as the store for wealth, while in drawing long leases of college lands, it was stipulated that rents should be paid in wheat. History has proved that gold is subject to far less fluctuations in value than almost anything else; it is thus the best possible standard of value as well as measure of it. For a substance to be fit to be used as money it should be portable, indestructible, divisible, homogeneous, stable in value workable, cognisable, highly prized. It will be seen that gold and silver combine many of these qualities in a remarkable degree.

A pound sterling has been the standard of value in England since the time of William the Conqueror. It then consisted of a troy pound of silver. It became less and less till, in 1717, it was only four ounces. In that year it was decreed that 113·001 grains of fine gold should henceforth be the corresponding golden pound. It was not till a century later that gold pound pieces were struck. A pound sterling and a sovereign are now the same thing. The sovereign is not made of pure gold; it contains $\frac{1}{12}$ alloy. Its weight is 123·27477 grains. Coins are issued between the weights of 123·074 and 123·474 grains, and they are legally current so long as they do not weigh less than 122·5 grains. As a fact, however, they are often several grains less than that.

12. Explain the terms convertible and inconvertible, as applied to paper currency, and trace out the different effects of a large issue of either. How is the convertibility of Bank of England notes secured?

Notes are convertible when they can be exchanged for gold on presentation at the bank where they are issued. They are called inconvertible when they cannot be so exchanged. Paper

money is merely an instrument to economise the use of gold. It is plain that if the issue department of a bank retained all the gold for which it issued notes, it would have the means of cashing the whole of the notes whenever they might be presented. The gold thus stored up in the issue department belongs to the persons who hold the notes. The issue department of the Bank of England is bound by the Act of 1844 to retain gold for every note issued beyond a fixed sum, which is now fifteen millions; and they hold securities which are immediately saleable for the fifteen millions. Hence they are able to cash as many notes as are presented. If the gold threatened to run short, some or all the fifteen millions of government securities could be sold, and every note issued could be cashed. The total note circulation is often forty millions sterling. A large government contract could be paid for entirely in Bank of England notes, the government having deposited gold in the issue department for the notes. The contractor would pay these notes away in any manner he chose. They would then be in the hands of the public. So long as the public found it convenient to use them they would remain in circulation, but no longer. There would be no depreciation in their value because of their convertibility. It is quite otherwise with inconvertible notes. A large issue of such notes, say in St. Petersburg, would at once lead to a depreciation in the paper currency. People might have more of them than they wanted. They would not circulate outside the Russian empire. Payments in gold might be necessary, and the holders of these inconvertible notes would have to part with them for what they could get for them. Every fresh issue in excess of the needs of the public would have a similar effect.

13. To what causes has been due the great depression of English agriculture of late years? Comment on the proposal to re-impose a duty on corn.

The depression in English agriculture has been severe and prolonged. Bad seasons and falling prices resulted in the financial ruin of thousands of farmers. Rents fell, but not in many cases till the farmers had lost all their money. Bad farming, insufficient capital, sometimes ruinous borrowing, only served to increase the distress. Matters have gone from bad to worse, until it may be fairly affirmed that many farms are not producing more than half what they are capable of. All the while prices have been falling. The splendid soil, the energetic farming in America and the Colonies, the improved and cheapened means of transit, have brought cereals, meat, and dairy produce to our shores at prices lower than any known before. It is no wonder that a proposal should be made to re-impose a duty on corn; and if on corn, why not on meat and dairy produce generally? It seems already to be seen that the policy of saving agriculture at the expense of the nation would be as unwise, even if it were possible. It would not save agriculture. It might do something for landlords (who are indeed to be pitied), but it would not save agriculture as now carried on. Nothing can save it. It is doomed. Not that there is no future for farming in this country. With so many millions to supply with milk, eggs, meat, butter, vegetables and fruit, the future is full of hope. But agriculture must be conducted on scientific principles, and with abundance of capital for the supply of manure, implements, and skilled labour.

14. Prepare the notes of a lesson to an advanced class on one of the following passages:—

(i.) Consols were on Friday, October 7, 102 to 102¼. Bank rate at 4 per cent.

(ii.) Industry is limited by capital.

(iii.) Banking transfers capital from the inactive accumulator to the energetic person who wants capital.

(1) This country often engaged in serious wars; these cost large sums of money. After the time of Queen Ann the money was borrowed of the people, and interest paid for it at 3 per cent. Such money was called the National Debt. This has grown to a very large sum. It was about 16 millions at the accession of Queen Ann, about 54 millions at the accession of George I., about 128 millions at the beginning of the American War, about 230 millions at the beginning of the French War, and about 840 millions at the present day.

Consols is short for consolidated. People who hold this stock and want money do not get capital back, but sell their stock. A man called a broker can always find some one in the building called the London Stock Exchange who is willing to buy or sell this Stock. On the 7th of October he would buy it at 102 and sell it at 102⅛, the difference being his profit.

Consols were at 102 and pay 3 per cent.; they therefore really pay less than 3 per cent.

Bank rate 4 per cent. The bank means Bank of England. It was willing that day to cash Bills of Exchange, that is, pay them before they were due, at the rate of 4 per cent. interest until they became due; *e.g.*, a man might have a piece of paper promising to pay him £100 in 3 months hence. He might want the money at once. The Bank of England (and some other houses) would have paid him

$$£100 - \frac{100 \times 4}{100 \times 4} = 1 = £99.$$

less a small charge or commission.

If the bank is short of lendable money it may charge 10 per cent.; sometimes it only charges 2. If the rate is high foreigners send us gold in payment of their accounts instead of pieces of paper which have to be discounted.

(To be continued.)

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Science Notes.

THE Science and Art Department has again issued the report of the examiners on the results of their work. Altogether 18 reports have been published. The remarks on the answers to the questions in the first three stages of Mathematics are given with the usual minuteness, and teachers will do well to note the points where weakness was most manifest. It is pleasant to note that in the geometry all the questions came in for a fair share of attention, and there was evident a somewhat greater power of dealing with deductions than heretofore. In theoretical mechanics there was a large increase in the number of candidates for the elementary stage, and a fair increase for the advanced. The work on the whole seems to have been very well done. The report on the subject of light and heat is as brief as ever. It states that the answering in the advanced paper, and also in the elementary paper, showed some improvement since last year's examination, but that the optics is still badly done and the impression is produced in the mind of the examiners that the teaching in this subject is faulty. The examiner in the subject of Steam states that the sketching of figures has greatly improved, and considering the difficulty of treating the subject and the limited opportunities which many students naturally have of examining details of construction, is highly creditable. In Geology there is also good progress, some of it due to the improved education of the pupils, but due in no small measure to the improved character of the teaching. The more frequent use of the blackboard for sketches is recommended. The Examiner in Mineralogy remarks that the teaching in crystallography and in the use of the blowpipe is far from satisfactory. He adds that while some of the papers in the elementary stage are decidedly good and reflect credit upon the teachers, yet apparently in the same classes there are pupils whose answers are often so grotesquely stupid that the natural inference would be that they had not been taught at all. This is an observation which many examiners would do well to lay to heart. They often draw very positive conclusions as to the teacher and the teaching from reading the answers to examination questions. Have they not often been a good deal taken aback by the answers of their own pupils?

The examiners in Physiology are not satisfied. 'Gross errors are fewer, but that is owing to the attention which

the examiners have drawn to conspicuous blunders. The teachers teach much in the same way as they did, and teach about the same things.' This is discouraging; and you may so far discourage a teacher as to make a failure of him. Would it not be well to withdraw this subject from the science directory. Teachers do not seem to be able to teach it, nor does the department think it worth while to enlighten them by summer courses in this subject. If this is going too far, would it not be wise to insist that no pupil should be presented in physiology who had not passed in the new elementary stage of chemistry; and is it not high time to re-write a new elementary stage for general Physics, which would be useful to students in nearly all branches of science?

The Botany seems, in many cases, to have been well done. In the honours all the candidates showed knowledge of microscopic work, and the identification of specimens was well done. In the elementary stage the descriptions were poor, the diagnosis of the order usually being extremely weak or altogether omitted. This is of course not surprising, seeing that Botany has to be studied in the winter months. The department could produce a marvellous change in the results on the subject of Botany by putting the examination in October. It is hardly likely that another institution in the world examines in Botany just before there has been a good opportunity of getting fresh specimens. In the subject of Agriculture there has been great improvement in the elementary stage, and material progress in the advanced stage. 'The teachers engaged in the work are acquiring a sound and intelligent acquaintance with it.' This is high praise and will give pleasure and stimulus to the men who are doing a very important work at a critical time in English agriculture. Taken as a whole, the remarks of the examiners will be helpful to teachers who will no doubt be glad to know where their pupils failed to give satisfaction. It strikes us that a conference between examiners and teachers would be most useful and lead to good results. It is high time that both classes should work together with a single object in view. At present examiners often speak as though they had little respect or sympathy for the teacher, who in turn comes to regard an examiner as a natural enemy.

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THE XXII. volume of the report of the Zoological results of the *Challenger* expedition has just been issued. It contains the report of Dr. Günther, of the deep sea fishes collected during the cruise. It is found that at a depth of 100 fathoms the sunlight becomes extinguished and the real deep sea life begins, but with a large admixture of surface forms. The number of species is found to diminish as the depth increases, so that while there may be abundance of individuals there are not many kinds of them. A marked feature of these deep sea forms is their phosphorescent organs. Professor H. N. Moseley gives an account of those on the head of the Ipnops, a fish in which the eyes as well as the optic nerves are entirely absent. A pair of luminous organs are to be found on either side of the median line of the upper surface of the head, the upper wall of the skull where it covers them being completely transparent.

SYDNER LUPTON, whose admirable little book, Numerical Tables and Constants in Elementary Science, ought to be in every teacher's hands, has again drawn attention to the subject of computation. A paper of his appeared in the Journal of Education, in May, 1885, and will well repay an attentive reading. He has returned to a special aspect of the subject in 'Nature,' for January 5th. He gives some interesting instances of the want of accuracy in computation. Newton, we are told by Lord Lytton, great master as he was of calculations the most abstruse, could not cast up a sum in addition. Nothing brought him to an end of his majestic tether like dot and carry one. In Huxley's Physiography, 1st edition, we read that the weight of air on a square mile is about 590,129,971,200 lbs, and the carbonic acid which it contains 3,081,870,106 lbs, or about 1,375,834 tons. The weight of the carbon in this is 371,475 tons. Here the first number is ten times too great, and not quite accurately calculated from the data $(5280)^2 \times 144 \times 14.73 = 59,133,431,808$. Multiplying this by $\frac{.05321}{1000}$ the proportion by mass of carbonic acid in the air, we obtain 31,464,899; here, beside a slip, the number is again ten times too large. The pounds are reduced to tons correctly, but there is a slip in the reduction to carbon since $\frac{1,375,834 \times 3}{11} = 375,227$. Mr. Lupton says that the teachers of arithmetic in our public and higher grade schools are usually good mathematicians, who in their own school days have been hurried through the hated subject to higher work, and have had no subsequent experience in the practical computation required in the laboratory, workshop, or counting-house. He names three points in which, for a science student, the existing arithmetics are defective: (1) in devoting so much attention to sums in money; (2) in neglecting to give suggestions for the use of such tables as will lighten arithmetical work; (3) in neglecting the treatment of approximate quantities. De Morgan's arithmetic contains an excellent appendix on computation. It is a pity it is not better known and more used.

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Recent Inspection Questions.

Arithmetic.

STANDARD I.

1. Add 27, 604, 318, 9, 640.	1,598. Ans.
2. From 843 take 96.	747. Ans.
3. From 327 take 89.	238. Ans.

STANDARD II.

A.

1. From 74,312 take 6,027.	68,285. Ans.
2. Multiply 83,746 by 8.	669,968. Ans.
3. Multiply 6,427 by 76.	488,604. Ans.
4. Divide 14,733 by 9.	1,637. Ans.

B.

1. From 68,052 take 8,206. 59,846. Ans.

2. Multiply 74,835 by 9. 673,515. Ans.

3. Multiply 7,362 by 68. 500,616. Ans.

4. Divide 12,383 by 7. 1,769. Ans.

STANDARD III.

1. I bought a carpet for two guineas and a hearth-rug for half of a five pound note; find the change out of five sovereigns. Eight shillings. Ans.

2. Add £10,598 16s. 9d. to £5,069 18s. 6d.
£15,668 15s. 3d. Ans.

3. Divide 709,638 by 406. $1,747\frac{356}{406}$. Ans.

4. If 405 trains convey 5,678 passengers each, how many passengers are conveyed altogether?
2,999,590. Ans.

STANDARD IV.

(*Boys.*)

1. What is the daily income of a man who receives £769 18s. 5¼d. in a year? £2 2s. 2¼d. Ans.

2. Find the number of ounce packets in 8 tons 18 cwt. 2 qrs. 10 lbs. 320,032 packets. Ans.

3. Two boys went for a walk, and one of them walked 110,880 inches further than the other. How many miles, furlongs, &c., would that be?
1 m. 6 fur. Ans.

4. A shopkeeper took on Monday £6 18s. 6d., on Tuesday £17 19s. 6d., on Wednesday £15 12s. 4½d., on Thursday £19 2s. 7¾d., and on Friday he took £7 10s. 6d. less than he did on Saturday. The money taken during the whole week amounted to £104 16s. 8d. What was received on Friday.
£18 11s. 6¾d. $\frac{1}{4}$ Ans.

STANDARD V.

A.

1. If 750 inches make 25 coats, how many will 870 inches make? 29 coats. Ans.

2. $\frac{1}{2} + \frac{2}{3} + \frac{6}{8} + 1\frac{7}{12}$. $2\frac{1}{3}$. Ans.

3. 1,500 articles at 6s. 10d. each.
£512 10s. Ans.

4. Make out the following bill:—
50 candles at 14s. 7d. per hundred;
31 lbs. of rice at 3½d. per lb.;
14 ozs. of tea at 4½d. per oz.;
and take the answer from 30 shillings.
30s. — (7s. 3½d. + 8s. 4¾d. + 5s. 3d) =
9s. 0¾d. Ans.

B.

1. $(\frac{2}{3} + \frac{1}{6}) - (\frac{2}{3} + \frac{3}{10})$. $\frac{2}{15}$. Ans.

2. If 18 cows are grazed 12 days for £10, how long should 42 cows be grazed for the same money?
8 days. Ans.

3. 18 acres 2 roods 25 poles @ £5 17s. 6d. per acre. £109 12s. 1½d. Ans.

4. A bill:
6 lbs. 12 ozs. at 3s. 6d. per lb.; 9 lbs. at 5d. per lb.; 30 cakes, each 4½ lbs. weight, at 7d. per lb.; 1,000 halfpenny buns; 5½ doz. loaves at 6½d. each.
£1 10s. 7½d. + 3s 9d. + £3 18s. 9d. + £2 1s. 8d. + £1 15s. 9d. = £9 10s. 6½d. Ans.

C.

1. A ship sails 120 miles in a day. If the voyage takes 6 days 8 hrs. what is the length of the voyage?
760 miles. Ans.

2. $\frac{4}{5} + \frac{1}{2} + \frac{7}{9} + \frac{5}{6}$. $2\frac{41}{45}$. Ans.

3. Find by practice what should be paid for 275 tons of hops at £3 16s. 8½d. per cwt.?
£21,094 15s. 10d. Ans.

4. I borrowed £5 from a friend who was travelling with me, but I paid for him—(*a*) The hire of a carriage, 15 miles at 1s. 3d. per mile. (*b*) Bedroom at an hotel, 4 nights at 2s. 3d. per night. (*c*) Board for 4 days at 7s. 6d. per day. How much do I still owe him? £2 2s. 3d. Ans.

STANDARD VI.

A.

1. Find the simple interest on £987 17s. 6d. for 7½ years at 4 per cent. per annum.
£296 7s. 3d. Ans.

2. If 2 roods 30 perches require 7 cwt. 1 qr. of manure, how much will 3 acres 1 rood 5 perches need?
34 cwt. $2\frac{9}{27}$ qrs. Ans.

3. If 247 yards of cloth cost £4 2s. 4d., what will 18 pieces each $6\frac{5}{8}$ yards long cost?
£2 1s. Ans.

4. $\frac{5}{8}$ of 2 guineas + $\frac{1}{3}$ of 5s. 6d. — $\frac{1}{10}$ of 6s. 8d.
26s. 3d. + 1s. 10d. — 8d. = £1 7s. 5d. Ans.

B.

1. $(\frac{2}{7} + \frac{4}{13}) \div (\frac{8}{11} \times 5\frac{1}{2})$. $\frac{27}{182}$. Ans.

2. Find the value of ·3308 days.
7 hrs. 56 m. 21·12 secs. Ans.

3. What principal put out at simple interest at 5 per cent. will produce £69 in 1½ years?
£920. Ans.

4. A grocer bought 2 tons 6 cwt. 3 qrs. of sugar for £43 12s. 8d., and paid 18s. 2d. for carriage. How much must he charge per cwt. so as to make a clear profit of £10? £1 3s. 4d. Ans.

C.

1. If $\frac{3}{14}$ of a piece of land cost £789 15s. 6d., what would $\frac{1}{24}$ cost? £1382 2s. 1½d. Ans.

2. Find the interest on £764 at 3½ per cent. for 4 years 6 months. £120 6s. 7½d. Ans.

3. Reduce £1 2s. 3¾d. to the decimal of 4½ guineas.

·2361. Ans.

4. A worked 9 hours a day for 10 days, and B. worked 8½ hours for 12 days. They earned £6 between them. What was each man's share?

A, £2 16s. 3d. B, £3 3s. 9d. Ans.

Dictation.

STANDARD I.

House, stable, tall, trees, bones, young, birds, much, larger nests.

STANDARD II.

The donkey is a very patient animal, and content with very humble food. In drinking he refuses all water that is not clean. As he first came from warm parts, cold and wet make him very miserable. We should always be careful to give our donkeys warm and dry shelter.

STANDARD III.

An old fox closely pursued by a pack of hounds ran under the covert of a bramble. He rejoiced in this shelter and for a while was very happy. On trying to stir, however, he found he was wounded by thorns on every side. Although he was suffering pain he was afraid to leave the friendly briar.

STANDARD IV.

(*Girls.*)

They cut down trees with their teeth just like any woodman, and employ such parts of them as are adapted for the purpose. The plastering process is quite as curious as the building of the framework of the dam. Some say this is effected by means of a trowel such as masons use. You will perhaps smile at this, but they mean their tails, which seem well fitted for this work.

(*Boys.*)

The senses of smell, hearing, sight, and touch excel those of perhaps any other animal of the brute creation. Its powers of mind are not less well developed than its senses. Obedience, love for its master, docility, remembrance of ill or good deeds done to it, are marked features in the character of this animal.

Composition.

STANDARD V.

A man once had an eating house, but he found that it did not pay, as the men came in very hungry from the works, and consumed a great quantity of meat. He therefore thought of a plan to employ their minds and take their attention during the dinner hour. His daughter was a good player on the piano, and so he removed the instrument into the dining room. She played so well that the plan answered very well, for the men attended to the music instead of getting on with their meal. One day, however, a man entered who did not care for music at all, and he was not satisfied with what he got. When he left the room with the others he said, 'I wish that man would give us less music and more meat.'

Grammar.

STANDARD IV.

Sentence written on blackboard and parsed orally—

Amid the strings his fingers played.

STANDARD V.

Written exercise, parsing and analysis—

Nelson's coat and waistcoat are now well preserved at Greenwich.

STANDARDS VI. and VII.

Written exercise, parsing and analysis—

I am quite certain of this that you were not asleep.

Oral exercise—

What is a complex sentence? What does it consist of? How do we know an adverbial sentence? An adjective sentence? What word may always be substituted for a noun sentence?

Parse the words in italics:—

Written on blackboard.

On *Linden* when the sun was low
All *bloodless* lay the *untrodden* snow
And *dark* as winter *was* the *flow*
Of Isar *rolling rapidly*.

Pick out the subordinate sentence. Analyse it. How many sentences are there in the four lines?

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Publications Received.

Blackie and Son—

An Elementary Text Book of Physiology. By J. McGregor Robertson, M.A.

An Elementary Text Book of Dynamics and Hydrostatics. By R. H. Pinkerton, B.A.

Cassell and Co., Limited—

Cassell's New Standard Drawing Copies. Standards 5, 6, 7.

Chapman and Hall—

Mechanics and Experimental Science. By E. Aveling, D.Sc.

Curwen, J., and Sons—

Handbell Ringing. By C. W. Fletcher.

Deighton, Bell, and Co.—

Arithmetic Papers set in Higher Local Examinations, with Notes. By S. J. D. Shaw.

Fisher Unwin, T.—

The Story of the Nations: Ireland. By the Hon. Emily Lawless.—The Jews. By Prof. J. K. Hosmer.

Hibbert, Mrs.—

The Infant Action Song and Recitation Book. By Mrs. Hibbert.

(*Several announcements are unavoidably held over.*)

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The 'Practical Teacher' Sale and Exchange Column.

For Sale.—At one-fourth cost, large quantity of books suitable for Scholarship, Certificate, Matriculation, Civil Service, Oxford and Cambridge, French, German and Latin students.—Write for list, Mr. H. C. Stedny, 55, Richmond-road, Barnsbury, N.

For Sale, or Exchange for same value of standard modern literature.—*Four* of 'enlarged' edition of Angell's 'Magnetism and Electricity,' each 1s. 2d. *Two* of 'smaller' edition, 9d. each.—Address S. Roberts, British School, Falmouth.

Query Column.

RULES.

1. Each correspondent is restricted to *one question*. We should be much obliged if correspondents, who send questions for solution, would give (if possible) the required answer, and the source from which the question is obtained.

2. No query can be answered unless accompanied by the real name and address of the sender, not necessarily for publication, but as a guarantee of good faith and for facility of reference.

3. ☞ **When a pseudonym is adopted it should be written at the end of the query, and the real name and address on a separate piece of paper.**

4. Correspondents are requested to write their queries *legibly*, and on one side of the paper only.

5. Replies will not be sent through the post.

6. Queries must reach the office *not later than the 12th of the month*, or they cannot be attended to in the following issue.

*** All communications for this column should be addressed—'*The Query Editor*,' *The Practical Teacher*, *Pilgrim Street, Ludgate Hill, London, E.C.*

Algebra.

1. LILIPUTIAN.—Find the cube root of 1,371,742,108,367,626,890,260,631. (*Todhunter.*)

$31\}2$	3..	$\overline{1}371742108367626890260631(111,111,111.$ Ans.
$331\}2$	$31\}1$	1
$3331\}2$	363..	371
$33331\}2$	$331\}1$	331
$333331\}2$	36963..	40742
$3333331\}2$	$3331\}1$	36631
33333331	3702963..	4111108
	$33331\}1$	3699631
	37036629631..	411477367
	$333331\}1$	370329631
	370369629631..	41147736626
	$3333331\}1$	37036629631
	3703702962963..	4111106995890
	$33333331\}1$	3703699629631
	37037036629629631	407407366259260
	33333333	37037029629631
	37037036629629631	37037036629629631
		37037036629629631

Note.—See Rule 1 of Query Column.

2. IGNORAMUS.—Solve:—

$$\frac{1}{x}+\frac{1}{x+b}=\frac{1}{a}+\frac{1}{a+b}.$$

$$\frac{1}{x}+\frac{1}{x+b}=\frac{1}{a}+\frac{1}{a+b}$$

$$\frac{1}{x+b}-\frac{1}{a+b}=\frac{1}{a}-\frac{1}{x}$$

$$\frac{a+b-x-b}{(x+b)(a+b)}=\frac{x-a}{ax}$$

$$\frac{a-x}{(x+b)(a+b)}=-\frac{a-x}{ax}$$

$$\frac{1}{(x+b)(a+b)}=-\frac{1}{ax}$$

$$(x+b)(a+b)=-ax$$

$$x(a+b)+b(a+b)=-ax$$

$$x(a+b)+ax=-b(a+b)$$

$$x(2a+b)=-b(a+b)$$

$$\therefore x=-\frac{b(a+b)}{2a+b}.$$

As each side of the equation was divided by $a-x$,

$\therefore a-x=0$, wherefore $x=a$

$\therefore x=a$, or $-\frac{b(a+b)}{2a+b}$.

3. JEAN.—An annuity of £20 a year for 21 years is sold for £220; what rate per cent. did he get for his money?

Let A be the annuity in pounds, n the number of years, r the interest of one pound in one year, and P the present value.

Then, $P=\frac{nA+\frac{1}{2}n(n-1)rA}{1+nr}$, allowing simple interest.

(See *Todhunter.*)

$$\therefore 220=\frac{21\times 20+\frac{21}{2}(21-1)\times 20r}{1+21r}$$

$$11=\frac{21+\frac{21}{2}\times 20r}{1+21r}$$

$$11(1+21r)=21+210r$$

$$11+231r=21+210r$$

$$231r-210r=21-11$$

$$21r=10$$

$$\therefore r=\tfrac{10}{21}.$$

$\therefore$ Rate of interest $=100\times\frac{10}{21}$ per cent.

$=\frac{1000}{21}$ per cent.

$=47\frac{13}{21}$ per cent. Ans.

4. R. FISH.—M and N set out at the same time to meet each other from two places 343 miles apart, their daily journeys being in Arithmetic Progression, M's common difference being an increase of 2 miles and N's a decrease of 5 miles. On the day at the end of which they met, each travelled exactly 20 miles. Find the duration of each journey. (*Colenso.*)

$$l = a + (n-1)d;$$

For M: $20 = a + (n-1) \times 2$

$$20 = a + 2n - 2$$
$$22 = a + 2n$$
$$\therefore a = 22 - 2n.$$

For N: $20 = a + (n-1) \times -5$

$$20 = a - 5n + 5$$
$$15 = a - 5n$$
$$\therefore a = 15 + 5n.$$

$$S = (a + l) \times \frac{n}{2};$$

$$\therefore (22 - 2n + 20) \times \frac{n}{2} + (15 + 5n + 20) \times \frac{n}{2} = 343$$

$$(42 - 2n + 35 + 5n) \times \frac{n}{2} = 343$$
$$n(77 + 3n) = 686$$
$$3n^2 + 77n = 686$$
$$n^2 + \frac{77n}{3} = \frac{686}{3}$$
$$n^2 + \frac{77n}{3} + (\tfrac{77}{6})^2 = \tfrac{686}{3} + \tfrac{5929}{36}$$
$$= \frac{8232 + 5929}{36}$$
$$= \tfrac{14161}{36}$$
$$n + \tfrac{77}{6} = \pm \tfrac{119}{6}$$
$$\therefore n = \pm \tfrac{119}{6} - \tfrac{77}{6}$$
$$= 7, \text{ or } -\tfrac{98}{3}.$$

$\therefore$ Duration of journey = 7 days. Ans.

General.

1. G. W.—You will find the solution of the equation in the Model Answers to the Certificate questions in this number. As you state it is a difficult equation.

2. G. HILL.—Kindly give address. See rule 2 of the Query Column.

3. HASTINGS-MAN.—The proof is quite easy. Draw a horizontal line and let the object be at A and the glass at O then the image is at a distance of 2AO = say $2a$ inches from A. Now let the mirror be moved b inches farther back. It will then be $a + b$ inches from the object; the image now therefore will be $2a + 2b$ inches from the object. The image must therefore have moved $2b$ inches, while the mirror has moved only b inches, *i.e.*, the motion of the image is twice that of the mirror.

4. W. A.—Three forces will produce equilibrium when they can be represented in magnitude and direction by the three sides of a triangle taken in order. Now it is given that the three forces are inversely proportional to the three altitudes of a triangle and act in directions parallel to the sides upon which these perpendiculars fall. The three altitudes will themselves form a triangle which will be similar to the first and the forces they represent will therefore be in equilibrium.

5. CERTIFICATE.—The books you name would do very well. You should always read the query column, you will find many of the past answers suitable to you. You will find all you want in this Magazine during this year on the Educationist you name.

6. H. R. N.—No. If you read the syllabus you will see that the case does not admit of more than one interpretation. You do not mention which stage you mean to be examined in, we cannot therefore say whether any marks you would obtain would be put down to your credit if you were successful.

Owing to pressure on our space, we are compelled to hold over until our next issue the following papers: How to Teach the Babies, by James Bailey; Notes of a Lesson on the Shape of the Earth, by J. H. Cowham, F.G.S., as well as a large number of Reviews and several Queries.

Times.—'Perfect.'

Standard.—'Very complete.'

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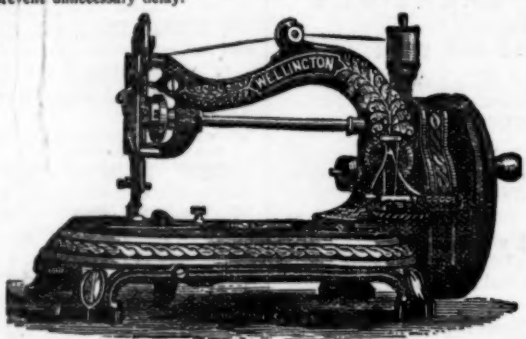

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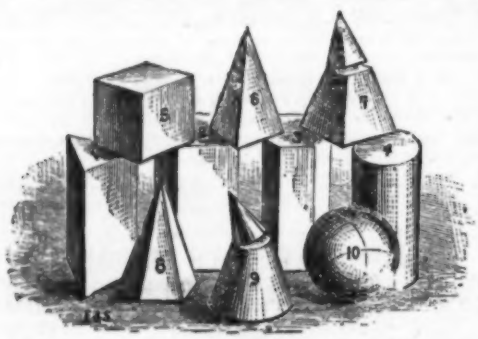

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